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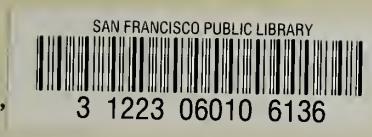

October, 1948

Report No. 128

NATIONAL BOARD OF FIRE UNDERWRITERS

COMMITTEE ON

FIRE PREVENTION AND ENGINEERING STANDARDS

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REPORT

ON THE

CITY OF SAN FRANCISCO, CALIF.

(Superseding that of 1939)

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The survey of conditions in San Francisco, California, was collected between September, 1947, and May, 1948, by Assistant Chief Engineer Herbert Raines and Engineers C. A. Weers and R. I. Eby.

Acknowledgment is made of valuable assistance rendered by the Honorable Elmer E. Robinson, Mayor; the officials of the various city departments concerned; the Board of Fire Underwriters of the Pacific; and others.

Office Engineers

Kenneth J. Carl
George J. Robinson
Willard H. Johnson

SAN FRANCISCO, CALIF.

REPORT No. 128

(Superseding that of 1939)

CITY IN GENERAL

Hon. Elmer E. Robinson is Mayor and, with the Chief Administrative Officer, presides over the administrative branch of the government. The legislative branch is made up of a board of eleven supervisors elected by the people.

Population is estimated at 800,000; a special United States census taken in 1945 showed 827,400, which included military personnel, and the 1940 census showed 634,536. The city is an important industrial commercial, financial and shipping center. It is the distributing point for an extensive tributary territory and serves a large retail and wholesale trade. As a port, it has 17½ miles of berthing space with storage warehouses for handling domestic and foreign commerce. Transportation facilities are afforded by three transcontinental railroads, several suburban lines, a municipal airport, and a state-wide system of modern highways. Bridges connect San Francisco with Oakland to the east and with Marin county north of the Golden Gate. The principal industries and products include printing and publishing, slaughtering and meat packing, metal working, wearing apparel, and bakery and other food products. Natural gas and oil are the principal fuels, the fuel for domestic use being almost entirely gas.

The city is located on the north end of a peninsula lying between San Francisco Bay and the Pacific Ocean. It covers a total area of 122.2 square miles, of which 44.8 square miles are land area of the city proper, 1.7 square miles are tidelands, and 1.0 square mile is in islands. Golden Gate park and the Presidio military reservation occupy about 10 per cent of the land area; of the remaining area, about 85 per cent is built upon.

Much of the city is built on the slopes of hills. Elevations in built-up districts range from tide water to 700 feet, with a few unoccupied hilltops as high as 900 feet. Throughout the residential districts, grades are numerous and steep with many of 10 to 34 per cent. In the congested value district, steep grades are confined to the edges of the district with a maximum of 25 per cent.

Street widths north of Market Street are mainly 69 feet; south of it, 82 feet. As of December 1946, there were 912 miles of streets in the city, of which 771 miles were paved, mostly with asphalt over concrete base, and 141 were unimproved or were included within government housing areas classed as temporary. Streets are generally in fair to good condition; many carrying street car tracks are rough. Railway crossings at grade seldom delay fire apparatus.

Records of the United States Weather Bureau station at San Francisco show that the prevailing direction of winds is from the west and velocities of 25 to 39 miles per hour are moderately frequent. Many winds in winter months are from the north and northeast, sometimes accompanied by low humidity. High winds reaching 40 to 50 miles per hour occur very infrequently and are generally from the northeast, southeast, or south. Since November 1944, relative humidity was between 13 and 30 per cent on 8 days when wind velocities were 20 miles per hour or greater. Temperatures are mild. Nine earthquakes of intensity sufficient to crack masonry walls and overthrow chimneys have occurred in the past 141 years; the most recent and severe was in 1906.

FIRE-FIGHTING FACILITIES

WATER SUPPLY

OWNERSHIP.—Works owned and operated by the municipality supply all closely built territory within the city and approximately 150,000 consumers outside, mainly in cities south of San Francisco. The first works were built in 1858 by a private company, the successors of which subsequently developed supplies south of the city and east of San Francisco Bay. The city purchased the system in 1930, and completed bringing in an additional supply from Hetch Hetchy in 1934.

An area of 14.2 square miles, including the congested value and adjoining mercantile, manufacturing and residential districts, is also protected by a separate high pressure fire system.

ORGANIZATION. — Works are under the supervision of the Public Utilities Commission, the members of which are appointed for four-year

terms by the mayor; Philip F. Landis, whose term expires in January 1952, is president and Lloyd S. Ackerman, Thomas G. Plant, Sam McKee and Victor S. Swanson, with terms expiring respectively in 1949, 1951, 1952 and 1952, are members. J. H. Turner, former manager and chief engineer of Hetch Hetchy water supply, power and utilities engineering bureau, has been manager of utilities since 1945; he serves at the pleasure of the commission and appoints or removes heads of departments subject to its approval.

The Hetch Hetchy system, including all portions of the supply works east of the Alameda east portal, is in charge of A. O. Olson, utilities engineer. The remainder of the system, since its purchase by the city has been in charge of the San Francisco water department of which N. A. Eckart is general manager and chief engineer. T. W. Espy, engineer of water production, has charge of construction, operation and maintenance of all supply works except Hetch Hetchy. George W. Pracy, superintendent of city distribution and O. G. Goldman, assistant superintendent, have charge of the operation of the system within the city. W. A. Yount is superintendent of the Alameda division and G. J. Davis, superintendent of the Peninsula division. Lawrence J. Archer is senior engineer. Officials are competent and experienced; long tenure is usual. There are approximately 440 regular employees, including 210 on the supply works and 230 on the distribution system. Employees are under civil service.

Records.—Records are generally complete, accurate, accessible and safely filed. Large scale maps of the distribution system, showing mains and valves, are supplemented by sketches of complicated intersections. There are pocket sized sectional maps for use by outside men. Records of hydrants are kept by the fire department. Specifications and detail plans of supply works are comprehensive. Records of consumption are complete. Charts from recording pressure gages, installed temporarily at numerous locations, are on file.

Quarters.—Main offices are in a fireproof building on Mason Street, between Post and Geary Streets. Pipe yards, shops and garage are on Bryant Street west of Fourth Street.

Fire Service and Emergency Operations.—Fire alarms are received at the main office and at the shops; records of alarms are kept. Response is made to second alarms. At night one gateman is on duty at the office with automobile equipped for emergency work; others can be summoned by telephone. Telephones are installed at the more important water works quarters and at residences of officials and responsible employees. A private telephone line connects most portions of the supply works.

GENERAL OUTLINE OF SYSTEM.—The chief source of supply is the Hetch Hetchy system which obtains water from the Tuolumne River and its tributaries in the Sierra Nevada Mountains 150 miles east of the city. Other sources are the drainage areas of several valleys which unite in Alameda Creek, and a well field, 33 miles southeast of the city; and three adjoining watersheds on the peninsula 6 to 18 miles south of the city.

The supply is delivered to the city by gravity and pumping through five conduits. Distribution within the city is in seventeen services, which for consumption purposes are grouped in six districts. Three of the districts, including the two most important are supplied by gravity, another by gravity with supplemental pumping and the other two, by pumping with equalizing storage.

Elevations in this report are referred to city base, which is 8.74 feet above mean sea level.

HETCH HETCHY SYSTEM. — General. — This source is designed to provide an ultimate water supply of 400,000,000 gallons a day and hydro-electric development of 250,000 horsepower. It includes storage reservoirs at high elevations, tunnels through Sierra Nevada Mountains and foothills, a steel pipe line across San Joaquin Valley, tunnels through the Coast range, submarine pipes under a narrow section of south San Francisco Bay, and a connection to Crystal Springs reservoir. It is operated by gravity and has a total length of 167 miles.

The watersheds lie on the westerly slopes of the Sierra Nevada Mountains; of their total area 88 per cent is within Yosemite National Park and the remainder in Stanislaus National Forest. The rights to utilize public lands to impound water from the 713 square miles drained by Eleanor and Cherry Creeks and the upper Tuolumne River, were granted the city by Congress in 1913. Drainage areas lie between elevations 2,350 and 13,000 with 90 per cent of the area above the 6,000-foot contour. They are largely of rugged granite formation, thickly forested in places and uninhabited. Precipitation for 36 seasons at Hetch Hetchy on the lower part of the watershed averaged 33.62 inches, with minimum and maximum seasons of 17.03 and 55.62 inches.

Hetch Hetchy Reservoir.—See Table 1. This reservoir, 145 miles east of the city and 18 miles northwest of Yosemite Valley, impounds on the upper Tuolumne River and has a catchment area of 462 square miles. At this point the flow of the river for a 49-year period has averaged 672 million gallons a day, with a minimum year and 6-month period at the rate of 248 and 7 million gallons a day, respectively, and a maximum flood discharge of 50,000 second-feet. The reservoir is formed by the O'Shaughnessy Dam, a cyclopean concrete gravity dam arched upstream on a 700-foot radius and constructed on a granite floor and

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TABLE 1.—RESERVOIRS AND TANKS

Name	Year Built	Elevation High Water	Available Depth, Feet	Capacity, Million Gallons	Supplied From	Supplies
HETCH HETCHY SYSTEM						
Hetch Hetchy Res.	1923	3796	303	111,110	Watershed run-off	Priest Reservoir
Lake Eleanor	1918	4648	50	9,000	Watershed run-off	Priest Reservoir
Priest Reservoir	1923	2233	95	765	Run-off, Hetch Hetchy & Lake Eleanor	Moccasin Power Plant
Moccasin Re-reg. Res.	1929	913	40	162	Priest Res. via Power Plant	Aqueduct to Crystal Springs
ALAMEDA and PENINSULA DIVISION RESERVOIRS						
Calaveras Res.	1925	753	198	31,600	Watershed run-off	Aqueduct to Crystal Springs
Niles Reservoir	1923	181	15½	5	Pleasanton Wells & Sunol Filter Beds	Irvington Pumps
Pilarcitos Res.	1867	692	53	1,000	Watershed run-off	San Andreas Res.
San Andreas Res.	1868	441	79	6,000	Run-off, Pilarcitos, Crystal Springs Pumps	Sunset and College Hill Res.
Crystal Springs Res.	1890	284	140	22,500	Hetch Hetchy, Alameda sources & Run-off	Univ. Mound and Merced Manor Res.
Lake Merced*	1891	18	10	2,500	Springs	Lake Merced Pumps
DISTRIBUTING RESERVOIRS IN CITY						
University Mound	1924	172	26	59.4	Crystal Springs Res.	University Mound Service
University Mound	1937	172	26½	81.5	Crystal Springs Res.	University Mound Service
Francisco Street	1878	135	8	2.5	University Mound Res.	University Mound Service
College Hill	1870	255	17	13.5	San Andreas Res.	College Hill Service
Lake Honda*	1915	370	36	45.2	San Andreas Res.	Sunset Service
Sunset	1938	385	31	89.4	San Andreas Res.	Sunset Service
Lombard Street	1860	303	16	2.7	Sunset Reservoir	Lombard Street Service
Potrero Heights	1897	315	21½	1.0	Sunset Reservoir	Potrero Heights Service
Merced Manor	1936	187	21	9.5	Crystal Springs Res.	Merced Manor Service
Wilde Avenue	1902	400	10	0.5	Olmstead Pump Station	Wilde Avenue Service
Stanford Heights	1925	614	20	10.6	Central Pump Station	Stanford Heights Service
DISTRIBUTING TANKS IN CITY						
Meyer	.....	215	11½	0.020	Sunset Service	Meyer Tank Service
Keith Street	1943	290	11	0.230	Lane Pump Station	Keith Tank Service
Hunter's Point Housing	1943	290	18	0.380	Keith Street Tank	Hunter's Point Housing
Potrero Heights Tank	1948	355	22	0.100	Potrero Heights Pump	Potrero Hts. Tank Service
Lincoln Park*	1924	370	20	0.075	Lincoln Park Service	Lincoln Park Service
Presidio Heights*	1903	400	33	0.700	Regulators from Stanford Hts. Serv.	Presidio Heights Service
Crocker*	.....	520	7½	0.008	Stanford Heights Service	Stanford Heights Service
Clarendon Heights*	1895	600	14	0.500	Stanford Heights Service	Stanford Heights Service
Fairview	.....	700	10	0.020	Fairview Pump	Fairview Service
Forest Hill	1926	800	25	0.300	Forest Hill Pumps	Forest Hill Service
Forest Hill	1945	800	26	0.300	Forest Hill Pumps	Forest Hill Service
Twin Peaks	1946	844	19	0.100	Twin Peaks Pump	Twin Peaks Tank Service

*In reserve.

abutments. The dam was built to a height of 344½ feet in 1923 and 85½ feet was added in 1938; 118 feet is below the stream bed. The crest is 900 feet long and 25 feet thick. The base is 308 feet thick.

The dam has contraction joints with copper water stops, inspection galleries and wells, and a complete drainage system. The spillway is of the side-channel overflow weir type with a capacity of 50,000 second-feet; the spillway crest is 16 feet below the top of the dam. Outlet to the river below is provided through two 6-foot, six 5-foot and six 3-foot conduits each of which is equipped with a slide valve; in addition thirteen have balanced needle valves and one has a butterfly valve. In emergency each conduit may be closed by lowering a steel shutter through a slot in the wall of the outlet structure. The larger conduits are arranged in pairs at four levels to discharge water in quantities up to 4,000 second-feet for irrigation rights. Three of the smaller conduits are on the lower side of the dam at elevation 3,617 and three are in the former diversion tunnel at elevation 3,508, permitting the complete emptying of the reservoir. The discharge from the reservoir flows 12 miles down the Tuolumne River bed to the Early intake.

Lake Eleanor Reservoir.—See Table 1. The Lake Eleanor reservoir, 5 miles northwest of Hetch Hetchy reservoir, impounds the waters of Eleanor and Frog Creeks and has a catchment area of 79 square miles. It was built to provide water for generating electric power during the construction of the Hetch Hetchy project. The capacity of the present reservoir is only a small part of the annual run-off of the watersheds which for the past 37 seasons has averaged 143,000,000 gallons a day. It is proposed ultimately to increase its capacity to 70 billion gallons. It is formed by a multiple buttressed-arch concrete dam, founded on bed rock, and has a total length of 1,260 feet and a maximum height of 70 feet. The spillway near the east abutment is of overflow gravity type, 200 feet long, and is provided with removable flashboards raising the water level 5 feet. There are four 24-inch outlets in the base of the dam.

Cherry Creek Conduit and Power House.—The supply from Lake Eleanor flows 4 miles down the natural bed of Eleanor Creek to its confluence with Cherry Creek, on which a future reservoir is proposed to impound the run-off of 111 square miles and to contain 88 billion gallons at elevation 4,700. Natural flow of Cherry Creek has averaged 237,000,000 gallons a day for the past 37 seasons. Four miles below the junction the supply is diverted by a concrete dam into the Cherry Creek conduit, consisting of 1.09 miles of concrete lined canal, 0.82 mile of steel pipe and 1.79 miles of tunnels and having a capacity of 130,000,000 gallons a day. A 42-inch penstock with drop of 350 feet operates a power house on the Tuolumne River containing three 1,200-kw. generators. Cherry Creek conduit has been extended ½ mile to Early intake. A proposed aqueduct from Lake Eleanor and the projected Cherry Creek reservoir will permit generating 52,000-kw. near this point.

Early Intake. — The Early intake, which receives the run-off from an area of 61 square miles in addition to the above sources, consists of a concrete diversion dam of arch type having crest at elevation 2,349. It is 262 feet long, 6 to 16 feet thick and has a total height of 81 feet. Base and abutments rest on solid granite. The spillway is to the north of the dam, of overflow gravity type, 115 feet long, with crest at elevation 2,334 and a capacity of 20,000 second-feet. Automatically operated radial gates maintain water surface at elevation 2,339 and lower themselves during floods. A gate structure containing 9 head gates, manually operated travelling screens and a sand chamber, admits water into a concrete lined canal ½ mile long, which extends to the Mountain tunnel.

Mountain Tunnel.—Of the tunnel, 11.65 miles are of 10.25-foot horseshoe section lined with at least 6 inches of reinforced concrete and 7.15 miles are in solid rock, approximately of rectangular section 13.33 feet wide and 13.5 to 14.25 feet high. A 9½-foot riveted steel siphon supported on concrete piers, and covered with heavy timber to prevent damage from rocks falling from the cliffs above, carries the supply 225 feet across the south fork of the Tuolumne River. The tunnel has a uniform slope of 8 feet to the mile and a capacity of 400,000,000 gallons a day. It empties into Priest reservoir.

Priest Reservoir. — See Table 1. The Priest reservoir, 120 miles east of the city, acts as a regulating reservoir for the Moccasin power house. It is formed by an earth and rock fill dam across Rattlesnake Creek and is 1,160 feet long, 145 feet high, with a base width of 660 feet, a crest width of 20 feet and a freeboard of 5 feet. The concrete core wall extends 15 feet into bed rock and is made in panels with copper water stops at the joints, to provide a certain amount of flexibility. Both toes are of rock fill. Earth on the upstream portion was placed hydraulically with a slope of 2½ to 1 covered with rip-rap. Earth on the downstream portion was placed by dumping from cars and being sluiced into place; the slope is 2 to 1. The concrete lined spillway, 40 feet wide, has lip at elevation 2,240. Valves set in a reinforced concrete outlet tower control the flow into a 6-foot concrete lined drainage tunnel, 973 feet long, constructed through bed rock at the east abutment.

Moccasin Power House.—The flow from Priest reservoir is controlled at a concrete tower in

which are six 6- by 8-foot sluice gates with bottom of opening at elevation 2,138. From it a concrete-lined tunnel, having a 13-foot horseshoe section, extends 5,370 feet to a surge tank 40 feet in diameter and 160 feet high. Three 104-inch riveted steel penstocks laid in tunnels and imbedded in concrete extend 535 feet where one is capped for future use and the others equipped with butterfly valves electrically operated from the power house. The penstocks have a total horizontal length of 5,349 feet and drop of 1,188 feet; they branch twice and reduce in size, entering the power house as eight 36-inch pipes under a pressure of 542 pounds. Pipes have wall thicknesses varying from 3/8 to 15/16 inches, are built in 30-foot sections with joints of various kinds appropriate to the diameter and pressure, and are supported on concrete piers and saddles. Heavy concrete anchors are provided at changes of direction, with expansion joints between anchors.

Current at 11,000 volts is generated by four 20,000-kv.-a. generators each driven by two 12,500-h.p. impulse water wheels. The station is a large steel frame building, having reinforced concrete walls and a tile roof, and with space provided for two additional units. Current is stepped up to 120-kv. at transformers set out-of-doors in banks of three and transmitted to Newark on the east side of San Francisco Bay over a two-circuit steel tower line 98.5 miles long, built on a private right of way.

Moccasin Re-regulating Reservoir.—This reservoir is formed by an earth fill dam across Moccasin Creek and permits uniform flow to the city irrespective of variable flow through the power house. The dam is 830 feet long, 73 feet high and has a crest width of 27.5 feet at elevation 920. It has a concrete core wall with a rolled clay section on both sides flanked by rolled earth; upstream and down-stream slopes are 2½ to 1 and 2 to 1, respectively; both faces are rock filled. The spillway to the north of the dam is of the concrete gravity overflow type. To prevent pollution to the supply by Moccasin Creek, there is a second dam across the creek above the tailrace from the power house, which diverts the creek flow through a 10-foot heavily reinforced concrete conduit constructed beneath both dams and the reservoir. The section under the lower dam serves also as a drain tunnel, the flow being regulated through a concrete outlet tower; a second outlet tower controls the flow from the reservoir into the Foothill tunnel.

Foothill Tunnel.—This tunnel resembles the Mountain tunnel in section, slope and capacity; 8.2 miles are lined and 7.6 unlined. At Red Mountain bar, 6 miles below the upper portal, the Tuolumne River and the Don Pedro reservoir of the Modesto and Turlock irrigation districts, are crossed by means of a 9.5-foot riveted steel siphon ½ mile long; the submerged portion is on solid rock and is covered with two feet of concrete. The upper portions are carried on structural steel bents, on concrete piers. Wall thicknesses vary from 3/8- to ¾-inch; joints in the lower portions are triple riveted butt joints and in the higher, double riveted lap joints. The siphon has seven expansion joints. The lower part is lined with 2¼ inches of concrete. The tunnel terminates at Oakdale portal, 4 miles southeast of Knights Ferry on the east side of the San Joaquin Valley; elevation of invert 747.

San Joaquin Pipe Line.—This line extends 47½ miles from Oakdale portal of the Foothill tunnel to Tesla portal of the Coast range tunnel, which is 7 miles south of the town of Tracy and 57 miles east of San Francisco. The line is entirely of electrically welded steel pipe, 56 to 72 inches in diameter, with a designed capacity of 60,000,000 gallons a day. It was laid in 30-foot lengths with riveted field joints; plates are 5/16- to ½-inch thick. The maximum head on the line is 550 feet. The first 8 miles and last 4 miles are mostly in rock, the balance of the line being in sandy loam. In addition to being asphaltum dipped the entire line has a second protective coating, half being a soil-proof wrapping and most of the remainder ½-inch of cement mortar; short lengths have 2- to 6-inch concrete shells.

The San Joaquin River and adjacent sloughs are crossed by a submerged pipe ½-mile long which rests on concrete saddles on pile trestles, has a 6-inch concrete envelope and a 1½-inch cement plaster lining. The pipe is laid under two smaller streams and a number of irrigating ditches. Railroads are carried over the pipe on heavy concrete structures at six points. The pipe is mostly on the same right of way as the power transmission line, which has a minimum width of 110 feet and is intended to accommodate two future pipe lines and another transmission line. Terminus is at elevation 392.

Coast Range Tunnels.—There are two tunnels, 25 and 3½ miles long, separated by 0.6 mile of 69-inch concrete siphon across the valley of Alameda Creek. Tunnels are circular, 10½ feet in diameter, lined with 6 to 24 inches of concrete, have a uniform slope of 2.64 feet per mile and an estimated capacity of 250,000,000 gallons per day. Considerable bad ground was encountered where the tunnel crosses fault zones. Water bearing seams in the rock were made as nearly tight as possible by grouting. Occasional occurrence of methane gas presented serious difficulties. The shorter tunnel terminates 2 miles east of the town of Irvington with invert at elevation 316.4.

Bay Conduits.—Two conduits extend 21¼ miles from Irvington portal of the Coast Range tunnel to Redwood portal of the Pulgas tunnel, which is 4 miles west of Redwood City and 23 miles south of San Francisco. The older line was

built in 1925 to carry water from the Alameda Creek system and has a capacity under gravity head of 45,000,000 gallons a day. Excluding two submarine portions crossing navigable channels in San Francisco Bay, the line is 60 inches in diameter and consists of double lap riveted steel 5/16- to 7/16-inch thick, excepting 1.33 miles, which is of 57-inch steel cylinder reinforced concrete pipe. The newer line was completed in 1936 and has a capacity of 69,000,000 gallons a day. Excluding submarine portions, it consists of 15 miles of 66-inch welded steel pipe 3/8- and 7/16-inch thick; 3/4-mile of 76-inch welded steel pipe 1/2-inch thick which is laid on a bridge; and 5 miles of 62-inch steel cylinder reinforced concrete pipe.

Both pipe lines are carried across 4 miles of marsh land on low redwood trestle bents on pile foundations and the newer one is protected from the weather by a board covering. Several gullies near the west end are crossed by carrying the pipes on steel bents on concrete bases. Other portions are laid in trenches with a minimum cover of 2½ feet. After laying, the lines were tested under hydraulic pressure 25 per cent greater than working pressure. There are sectionalizing valves and cross-connections between the two lines at several points.

The longer sub-aqueous crossing consists of three parallel lines 2,800 feet long laid under Dumbarton strait. The original line is 42-inch cast-iron pipe having walls 2 inches thick and lead caulked ball joints. The newer lines are 54-inch welded steel pipe with flanged joints, supported on a pile trestle in a trench dredged for the purpose and subsequently back-filled; the bottom of the pipes is 68 feet below water level. The pipe is of 3/4-inch steel, coated inside and outside with bituminous enamel and jacketed with 6 inches of reinforced concrete. At their westerly ends, the three submarine lines rise to a gated manifold housed in a concrete caisson which rests on piles and serves as an anchor to take unbalanced thrust. From the caisson, 60- and 76-inch lines are carried westerly on a steel bridge having 36 spans of 105 feet, supported on concrete piers resting on timber piles. There are expansion joints at intervals. The shorter submarine section, 400 feet long, is under the Newark slough and consists of a 42-inch cast-iron line and a 54-inch steel line, similar to the above.

Bay-Pulgas Pumping Station.—For details of equipment see Table 2. Located ½ mile west of the bridge. In emergency, pumps water from the Alameda Creek system into Crystal Springs reservoir. Takes suction under a head of approximately 130 feet and boosts it 180 feet by pumping around a closed 42-inch valve in the older conduit. Pumps have gated suction and discharge lines.

The station is a small, one-story building with concrete floor, wood frame and corrugated iron walls and roof. No exposures. Power is from either of two Pacific Gas and Electric Company transmission lines; transformers reducing voltage 60- to 4-k.v. are outside; wiring for light and power is in conduit. Protection is by portable extinguisher and small hose.

Pulgas Tunnel.—From the westerly terminus of the Bay conduits, the Pulgas tunnel extends 8,675 feet to Crystal Springs reservoir. It is lined with concrete having a minimum thickness of 6 inches, has a horseshoe section 10¼ feet in width and height, and a slope of 0.4 foot per 1,000. At each end there is a short length of reinforced concrete pipe 10¼ feet in diameter, one connecting to the Bay conduits and the other to a concrete lined outfall canal which discharges into the reservoir at elevation 290.

ALAMEDA CREEK SYSTEM — Calaveras Reservoir.—See Table 1. The Calaveras reservoir, 39 miles southeast of the city and 9 miles south of Sunol, impounds on Calaveras Creek and Arroyo Honda. The watershed of 100 square miles varies from rolling foothills to rugged mountains with steep slopes, and is wooded in few places. Rainfall varies from 13 to 30 inches a year with an average of 24½ inches. The reservoir is formed by an earth dam 220 feet high and 1,200 feet long. The lower part was placed hydraulically; the upper part has a diaphragm of impervious clay, supported on both sides by rock fill having comparatively flat slopes. The spillway is an open concrete lined channel in solid rock to the west of the dam, having a capacity of 22,000 second-feet and discharging into the stream bed.

A concrete outlet tower 12 feet in diameter connects with a concrete lined tunnel in solid rock through the west abutment of the dam. A 48-inch steel discharge pipe within these structures has four screened and gated inlet ports at various elevations and discharges either through a needle valve into the stream bed below the dam, or into a 44-inch pipe line which extends 5¾ miles northerly to a connection with the Alameda Creek siphon of the Hetch Hetchy system and permits gravity flow to Crystal Springs reservoir. The pipe, of 5/16-inch welded steel, is dipped and wrapped with a protective coating. It was installed in 1934, after three years service in another location. The normal yield of the watershed is estimated at about 30,000,000 gallons a day.

Upper Alameda Creek Diversion.—The water of Upper Alameda Creek is diverted into Calaveras reservoir through a tunnel 1.89 miles long. The catchment area of 30 square miles is similar to that of Arroyo Honda, described above. The reinforced concrete diversion dam, built in 1931, two miles northeast of the reservoir, is of buttress and slab type; overflow is at elevation 900. The tunnel is lined throughout and has a 6½- by 5½-foot horseshoe section; capacity is 420,000,000 gallons a day.

TABLE 2.—PUMPING STATIONS

Station	Elevation	Number and Type	Date of Mfr.	Capacity, Million Gal. Day	Water Pressure, Pounds	Electric Motor, H.P.	Pumps from	Pumps to
ALAMEDA and PENINSULA DIVISIONS								
Pleasanton Wells	350	14-Deep Well Turbine	1948	13.70*	5	30	Wells 12-14-inch 300 ft. deep	Sunol gravity line
Irvington	47	1 1-Stage Centrifugal	1941	21.00	145	1000	Niles 44-inch line	Hetch Hetchy Aque.
	47	1 1-Stage Centrifugal	1931	10.00	145	700		
	47	1 1-Stage Centrifugal	1931	12.00	145	500		
Pulgas †	15	2 1-Stage Centrifugal	1925	11.00	132	500	Alameda Creek System	Crystal Springs Res.
†	150	1 3 Parall. 1-Stg. Cent.	1913	20.00	40	400	Crystal Springs Res.	Boosts to Univ. Mound Res.
	150	1 1-Stage Centrifugal	1930	14.40	134	2-500		
Crystal Springs	146	1 1-Stage Centrifugal	1932	15.55	97	700	Crystal Springs Res.	Crystal Springs-San Andreas Aqueduct
	146	1 1-Stage Centrifugal	1932	22.75	95	1000		
Baden †	60	1 1-Stage Centrifugal	1931	15.55	97	700	Crystal Springs	San Andreas
	60	1 1-Stage Centrifugal	1941	21.60	95	1000	Trans. Line	Trans. Line
Lake Merced †	30	2 11x42 Horz. Cr. Com.	1891	3.70	212	‡	Lake Merced	Sunset Reservoir
CITY STATIONS								
Central	182	2 2-Stage Centrifugal	1929	9.00	211	§	Merced Manor Reservoir and San Andreas Trans Line	Stanford H'gts. Res.
†	182	2 2-Stage Centrifugal	1930	3.03	173	300		
Alemany	138	3 1-Stage Centrifugal	1931	15.00	124	900	University Mound Reservoir	College Hill Res.
Lake Honda	372	2 1-Stage Centrifugal	1940	0.60	15	5	Sunset Service	Lake Honda
	372	1 1-Stage Centrifugal	1948	1.20	15	10		Screen Tank
Forest Hill	400	1 3-Stage Centrifugal	1948	0.72	190	100	Lake Honda Screen Tank	Forest Hill Tanks
	400	1 3-Stage Centrifugal	1943	0.65	190	90		
†	400	1 9 x 10 Triplex	1920	0.35	190	50		
†	400	1 3-Stage Centrifugal	1930	0.75	90	50	Lake Honda Screen Tank	Forest Hill Tks. or Stanford Hts. Serv.
Francisco Street †	129	1 2-Stage Centrifugal	1930	3.03	173	300	Francisco St. Res.	Presidio Hts. Service
Olmstead Street	326	2 1-Stage Centrifugal	1934	0.20	35	5	Sunset Trans. Service	Wilde Ave. Res.
Lane Street	124	3 1-Stage Centrifugal	1942	0.32	65	15	University Mound Service	Keith Street Tank
†	124	1 2-Stage Centrifugal	1930	1.00	65	50		
Hunter's Point Housing	278	2 1-Stage Centrifugal	1943	0.30	20	5	Keith Street Tank	Housing Ridge Serv.
	278	2 1-Stage Centrifugal	1943	1.00	20	10		
Twin Peaks	585	1 5 x 8 Triplex	1937	0.13	110	10	Stanford Heights Service	Twin Peaks Tank
Lincoln Park	280	2 1-Stage Centrifugal	1946	0.39	30	7½	Sunset Service	Lincoln Park Service
†	5	1 2-Stage Centrifugal	1938	2.50	200	250	University Mound Service	Yerba Buena Island Reservoir
Bay Bridge	5	1 1-Stage Centrifugal	1938	1.80	150	125		
†	5	2 1-Stage Centrifugal	1938	0.29	55	10		
Potrero H'gts	310	1 1-Stage Centrifugal	1920	0.07	20	5	Potrero Heights Reservoir	Potrero Hgts. Tank
Bernal Heights	295	1 1-Stage Centrifugal	1934	0.07	35	2	Sunset Trans. Service	Bernal Heights Serv.

*Total of Group. †In reserve. ‡Three boilers, 160, 160 and 170 H.P. §Three boilers, 160 H.P. each.

Pleasanton Wells.—See Table 2. Near Pleasanton, 30 miles east of San Francisco and 5 miles north of Sunol, are 14 wells equipped with motor driven deep well pumps; at the time of this survey water stood at 48 feet below ground level. Two pumps are operated continuously to supply local demands and others discharge, through 5.32 miles of 30-inch pipe in poor condition, to Sunol at elevation 221. This source has not been used for city supply from the time Hetch Hetchy supply became available until the spring of 1948. The pipe line limits supply from this source to 13,700,000 gallons a day. Five additional wells may be equipped with pumps if the water level

drops to 80 feet or lower. Power from the Pacific Gas and Electric Company is transmitted from Livermore over a single aerial line.

Collecting Works.—The run-off from the three principal divisions of the watersheds unite in a narrow valley at Sunol, forming Alameda Creek. The confluence of the creeks is in a natural gravel bed of 1,300 acres, just above the mouth of the valley, where an underground concrete dam is located to raise the water plane to elevation 196. The water is collected through infiltration tunnels fed by a large number of small galvanized pipes penetrating the gravel bed and two 30-inch open concrete pipe lines. No surface storage is provided, but considerable water is retained in the gravel above the dam. The dependable yield from this source is estimated at 6,000,000 gallons a day.

Alameda Conduit.—Extends from the Sunol collecting works to the Niles reservoir and consists of 2.14 miles of concrete flumes mainly constructed in 1925 and of five concrete lined tunnels having a total length of 2.80 miles; capacity 70,000,000 gallons a day. A 36-inch pipe beyond the reservoir is no longer used as a transmission main.

Niles Reservoir.—See Table 1. Built ¾ mile east of Niles, at the end of the Alameda conduit, in excavation and embankment with lining of reinforced concrete and a wooden roof on concrete posts. The outlet is through a short 6- by 6-foot concrete lined tunnel to a 44-inch steel pipe which extends 2.96 miles southerly to a connection with the 60- and 66-inch Bay conduits of the Hetch Hetchy system; 6,000 feet of the 44-inch pipe is supported on wooden trestles. When the reservoir is being cleaned, use is made of a concrete tank, with water level at elevation 180.

Irvington Pumping Station.—See Table 2. Built adjacent to the connection of the 44-inch pipe from Niles reservoir to the Bay conduits at Irvington, this plant takes suction from the 44-inch line under a head of from 85 to 122 feet and discharges into either conduit against a head of 335 feet. Pumps have gated suction and discharge connections. One to three pumps are used, depending upon supply available; capacity of plant, 30,000,000 gallons a day.

The station is a small one-story frame structure with stucco exterior, concrete floor, composition roof and no serious exposures. Power, from the Pacific Gas and Electric Company over a single aerial circuit one mile long, is reduced from 12-k.v. to 2.4-k.v. by three 667-k.v.a. transformers on the ground outside; wiring for light and power is in conduit. Protection is by two 3-gallon carbon tetrachloride extinguishers.

PENINSULA WORKS.—General.—These receive the run-off from three watersheds having a total area of 36 square miles, 6 to 18 miles south of the city. The territory includes the higher elevations of the Peninsula extension of the Coast range, the slopes of which are sparsely to densely wooded. The San Andreas and Crystal Springs reservoirs are located over the San Andreas earthquake fault. Rainfall in various parts of the watersheds has averaged 34 to 50 inches a year, with minimums of 12 to 23 inches. The yield averages 15,000,000 gallons a day; for a three-year period following a series of dry years ending with 1931, the yield was 4,300,000 gallons a day. For essential data regarding reservoirs, see Table 1.

Pilarcitos Supply.—The run-off from a catchment area of 5.2 square miles is collected in the Pilarcitos reservoir, formed by a well constructed earth dam 90 feet high and 520 feet long. From the bottom of a brick and stone gate house, upstream from the dam, elevation 651, water flows 2.4 miles to San Andreas reservoir through a conduit composed of tunnel and steel pipe, capacity 45,000,000 gallons a day. The conduit crosses San Mateo creek, which is usually diverted by two small dams and flumes into the conduit or the Crystal Springs-San Andreas aqueduct. The run-off of the highest portion of San Mateo Creek watershed is diverted through 1,205 feet of 4½- by 4¾-foot tunnel into San Andreas reservoir. Stone dam, a small masonry structure 2 miles below the Pilarcitos dam, diverts waste water from the reservoir and the flow from several small streams through a conduit, composed of 0.34 mile of 39-inch concrete pipe and 0.70 mile of tunnel into San Mateo Creek which naturally flows into Crystal Springs reservoir.

San Andreas Supply.—The run-off from a catchment area of 8.4 square miles is collected in San Andreas reservoir, formed by a well constructed earth dam 110 feet high and 950 feet long. Surplus storage is diverted through a brick and concrete tunnel having a capacity of 1,000 second-feet into the stream bed below the dam and flows to Crystal Springs reservoir. An open channel concrete spillway, constructed in 1928, has a capacity of 2,500 second-feet. There are three outlets.

Two gate wells connect to a 42- by 54-inch brick lined tunnel, 2,820 feet long, terminating in a measuring tank, elevation 362. From the tank a 44-inch wrought iron pipe laid 1895 to 1898 extends 5.08 miles to Baden where it branches into two 30-inch lines one of which, laid in 1870, extends 8.14 miles to College Hill reservoir with a capacity ranging from 7,000,000 to 12,000,000 gallons a day by gravity. The second line, laid in 1907 and known as the Merced branch, extends 6.73 miles to Merced Manor reservoir with a capacity of 12,000,000 gallons a day.

The second outlet and conduit were installed in 1928. Two screens, consisting of steel drums

54 inches in diameter, 30 and 54 feet long and perforated with ¾-inch holes at elevations 400 and 422, connect through a vertical shaft with an 8-foot, horseshoe tunnel which extends 900 feet through a ridge on the east side of the reservoir. Gates control the flow into a standpipe in a vertical shaft, from which a 54-inch lockbar steel conduit extends 10.91 miles to a connection with a 44-inch line which can supply Lake Honda; capacity 30,000,000 gallons a day. The pipe is ½- to 7/16-inch thick, laid in 30-foot lengths, asphaltum dipped and felt wrapped. The line has a maximum head of 400 feet and was tested hydraulically to a pressure 50 per cent greater than working pressure.

The third outlet installed in 1947 between the older two has three screened inlets 84 inches in diameter, 25 feet long at elevations 390, 408 and 425 gated to a 60-inch riser in a 14-foot vertical shaft. The riser connects by 1,300 feet of 72-inch steel pipe laid in a concrete lined tunnel and 400 feet of 60-inch steel pipe, to a tee which branches to the two transmission lines to the city. The branch to the south consists of 5,800 feet of 30-inch pipe and connects to the 44-inch line. The branch to the north consists of 715 feet of 60-inch and 880 feet of 54-inch and connects to the 54-inch line with a 60-inch gated outlet for future connection at the point of reduction.

The 54-inch line is cross-connected to the two 30-inch supply lines at Baden. Just south of the city limits, a 30-inch branches and continues 3.14 miles through the Sunset Tranmission service. A mile further north the 54-inch supplies the so-called cross-town line, consisting of 1.06 miles of 44-inch and 2.30 miles of 36-inch, steel pipe, which extends easterly, is cross-connected to the above 30-inch and a 44-inch force main from Alemany pumps and terminates in a 36-inch supply main of the College Hill reservoir. Another branch 54 inches in diameter, begins a mile further north and continues 1.67 miles northwesterly to the Sunset reservoir.

Crystal Springs Supply.—The Crystal Springs reservoir receives the run-off from a catchment area of 22.5 square miles, and supply from Hetch Hetchy through the Bay conduits and Pulgas tunnel. It is formed by a concrete gravity arch dam 154 feet high and 600 feet long; its construction provides for an increase in height. A spillway of overflow gravity type, 80 feet wide, with removable flash boards, and having a concrete apron to protect the toe of the dam, discharges excess storage into the stream bed below the dam. The reservoir is divided into two parts by an earth dam 92 feet high and 520 feet long with crest at elevation 292.5.

There are two outlets. The older is through a brick gate well north of the dam a 54-inch pipe extending 359 feet through a 90-inch brick tunnel to a concrete chamber containing a controlling valve. The older conduit from this point to University Mound reservoir consists of ½-mile of 69- by 78-inch brick tunnel and 16½ miles of 44-inch wrought iron pipe laid in 1885; 1.3 miles of the latter crossing swamps and ravines are supported by timber trestles or concrete pier bridges and were extensively damaged by the 1906 earthquake. Capacity of conduit 25,000,000 gallons a day.

A second outlet, 300 feet north, consists of a 16-foot reinforced concrete shaft 85 feet high, containing a 60-inch steel riser connected to the reservoir at three levels by reinforced concrete tunnels; the flow through each may be controlled by two 54-inch gates in the shaft. From the bottom of the shaft a 78-inch pipe in a 10-foot tunnel extends 640 feet through the hill where it supplies the newer conduit to University Mound reservoir. To Burlingame, 4.8 miles distant, it is 60-inch welded steel ⅜-inch thick. From this point to Millbrae, 3.2 miles of 54-inch wrought iron pipe, laid in 1902, formerly used for the transportation of Alameda Creek water, is utilized. The remaining 11.2 miles is 60-inch pipe similar to the above, except that it includes three pressure tunnels having a total length of 0.77 mile. Tunnels are 60 inches in diameter, steel lined, with the space between the lining and the excavated bore, filled with concrete. The capacity of the line is 50,000,000 gallons a day.

Crystal Springs Pumping Station.—See Table 2. Located just below the Crystal Springs dam. The three newer units are used to raise water to a concrete lined canal which is 6.26 miles long, has a capacity of 55,000,000 gallons a day, and through which the supply flows to San Andreas reservoir. The older unit is used to boost the pressure in the 44-inch line to University Mound reservoirs when water in the reservoir is low. Current is obtained from the Pacific Gas and Electric Company over a private single 60-kv. overhead line from Millbrae, 7 miles distant; interruptions in service have been few in number and of short duration.

The station is a high, small area building having walls of wood posts and studs, plastered on metal lath on both sides. Concrete floor. Flat composition covered roof on wood sheathing on wood trusses. No exposures. Transformers are outside. Wiring for light and power in conduit. Lubricating oil kept in metal drum outside building. Protection is furnished by first aid fire appliances and garden hose.

LAKE MERCED SUPPLY.—This source has not been in regular use for a number of years, but formerly produced an average of 3,100,000 gallons a day. Supply from a drainage area of 8 square miles, mainly of a sandy formation underlaid by sandstone, is collected in Lake Merced, a reservoir

located in two natural lake beds 7 miles southwest of the congested value district. See Table 1. The surface run-off is diverted to the ocean to prevent pollution of the lake, but much of the rainfall on the drainage area enters the lake through springs in its bottom or on its margin. The lake is divided into 2 sections connected by gates and a low earth embankment separates it from the ocean.

Lake Merced Pumping Station.—See Table 2. Built in 1891 on the east shore of Lake Merced. Used to pump from the lake to the Sunset Transmission service. Suction is taken from the lake, with small lift, through 387 feet of 24-inch pipe, equipped with screens, gates and air pumps. Discharge is through 1.18 miles of 23-inch wrought iron pipe to a 30-inch distribution main. Boilers supply steam through a single line and a gated branch to each pump; one boiler is required for each pump in operation. Because of the long period of idleness it is considered that a week would be required to place this station in operation.

The three Babcock and Wilcox water tube boilers built in 1898, 1906 and 1907 and rated at 160, 160 and 170 horsepower, respectively, were last inspected in October 1933, at which time allowable steam pressures were 200, 200 and 160 pounds. Safety valves are reported set at 130 pounds pressure.

The station is an unexposed, corrugated iron and frame building, forming with connecting shed of similar construction, a single area of 6,500 square feet. Engine room floor, wood; boiler room floor, concrete. Natural gas and oil are used for fuel. Oil is stored in two 30,000-gallon wooden tanks housed in an iron clad building on adjacent hillside and six 3,000-gallon underground steel tanks near station. Protection is afforded by three extinguishers and 2-inch cotton rubber lined hose.

PUMPING STATIONS OF THE DISTRIBUTION SYSTEM.—General.—See accompanying map for locations and force mains from each, and Table 2 for equipment of the more important. Duplicate duplex oil pumps are provided at the Central station and fuel oil is maintained for emergency use. Electric power is obtained from the Pacific Gas and Electric Company, is from numerous sources and is considered reliable. Operation of Central station is continuous by 3 shifts of 3 men each. Alemany pumps are operated seasonally as required by one or more shifts of one man each. Francisco Street pump is operated a single shift by one man, during periods of peak consumption. Other stations are under automatic control and are visited as required except that an operator is required for the large pump at the Bay Bridge station.

Central Pumping Station.—Built in 1912 at Twenty-second Avenue and Sloat Boulevard, 5 miles southwest of the congested value district. Pumps take their supply either through a 30-inch connection from the 36-inch outlet pipe from Merced Manor reservoir, or through a 30-inch connection from a 30-inch Sunset Transmission service main under a head of 220 feet. Discharge is through 1.68 miles of 24-inch pipe to Stanford Heights reservoir. Three boilers are ordinarily operated; boilers supply a single steam line; natural gas and oil are used for fuel. The three Babcock and Wilcox water tube boilers, built in 1898 and rated at 160 horsepower, have current inspection certificates allowing 178 pounds steam pressure at which the safety valves are set. The station is a high, one-story building in a single area of 5,700 square feet. Side walls mainly of concrete; south wall has wood posts and intermediate studs; inside is plastered on metal lath and outside is covered with corrugated iron. Corrugated iron roof with slight pitch on steel trusses. A one-story frame shop of 1,600 square feet adjoins station on the south and twenty feet beyond there is a one-story frame storage building of 1,000 square feet. The four underground oil storage tanks alongside have a total capacity of 41,830 gallons. Wiring for power and light is in conduit; transformers in concrete vault within the shop annex. Fire protection is by 3 first-aid appliances and small hose.

Alemany Pumping Station.—Built to provide increased supply to the College Hill reservoir and service, this station takes suction under pressure from University Mound reservoir and discharges through a 44-inch force main 1.44 miles long into the 36-inch cross-town line to College Hill reservoir. The station is an unexposed one-story frame building with stucco exterior, concrete floor, wired glass skylights and composition covered wood roof; area 1,400 square feet. Wiring for light and power is in conduit. Power is from a single aerial circuit to a bank of three 12-2.4-kv. transformers safely installed outside. Fire protection is by 3 first-aid appliances.

Other Stations.—The Francisco Street pump takes suction from the Francisco Street reservoir and discharges into the northern extremity of the Presidio Heights service to maintain pressure during periods of high consumption. The other stations are in regular service, supply outlying residential districts at high elevations, and operate against equalizing storage. The Forest Hill station obtains suction from the 30-inch Sunset artery beside Lake Honda reservoir by way of Lake Honda pumps; it regularly supplies the Forest Hill service and in emergency can discharge into the Stanford Heights service; two pumps are ordinarily required. The Olmstead Street, Lane Street, Hunter's Point Housing, Twin Peaks, Palo Alto, Lincoln Park, Palace of

Legion of Honor, and Potrero Heights stations are equipped with small automatically operated motor driven pumps. The Bay Bridge station, located in the base of a concrete bridge pier, pumps from University Mound service to a government reservoir on Yerba Buena Island through a 9½-inch steel pipe on the Bay Bridge. The two small pumps and the largest are in reserve and manually operated, the fourth pump operates under automatic control.

Other stations are small frame buildings with wood, corrugated iron or stucco exteriors having roofs covered with wooden shingles or fire resistive materials, and wood or concrete floors. Exposures are severe at Lane Street and Forest Hill, moderate at Potrero Heights, Francisco Strcet and Hunter's Point Housing and negligible at others. Wiring for light and power is generally in conduit; transformers at Bay Bridge are in a concrete vault with metal door; at other stations transformers are outside. All pumping stations are within 500 feet of a fire hydrant and one mile of a fire station; Forest Hill has standpipes and hose and all have portable extinguishers.

DISTRIBUTING AND EQUALIZING RESERVOIRS AND TANKS. — See accompanying map for locations and Table 1 for essential details and uses. Excluding Lake Merced, reservoirs and tanks within the city have a total capacity of 318,500,000 gallons, all of which is above the level of the congested value district except for a few high blocks along Bush Street. Storage provides more than three days' supply for the entire city at the maximum day rate.

The two basins at University Mound, as well as the College Hill, Sunset, Merced Manor, Wilde Avenue and Stanford Heights reservoirs are constructed in excavation and embankment, and lined mostly with concrete. The newer basin at University Mound and the Sunset and Merced Manor reservoirs have reinforced concrete roofs. The Potrero Heights reservoir is in solid rock and the Francisco Street and Lombard Street, partly in embankment. Lake Honda occupies a natural depression with concrete lining. The Presidio Heights, Clarendon Heights, older Forest Hill and Keith Strect tanks are wrought iron or steel on solid rock; the Lincoln Park and newcr Forest Hill tanks are concrete and the other tanks, wood on trestles.

The University Mound, College Hill, Lake Honda, Sunset, Stanford Heights and Merced Manor reservoirs can be by-passcd. Reservoirs and tanks at lower elevations than others on the same service have automatic devices to prevent overflowing; the Presidio Heights tank and the Francisco Street and Lake Honda reservoirs are drawn upon only in extreme emergency. Tanks are in good condition considering their age. Watchmen are stationed at the more important reservoirs and water levels are reported twice daily.

CONSUMPTION. — Consumption within the six distribution districts and the city as a whole, is determined by meters on supply lines and at pumping stations. Consumption on the entire system was greatest during the fiscal year ending June 30, 1947, when it averaged 101,889,000 gallons a day, an increase of 74 per cent since our previous report. Within the city, consumption for the same period averaged 83,315,000 gallons a day and was divided as follows: University Mound 37.5 per cent; College Hill, 10.9 per cent; Sunset, 37.4 per cent; Stanford Heights, 12.0 per cent; Forest Hill, 0.9 per cent, and Merced Manor, 1.3 per cent. Consumption is controlled by the universal use of meters.

Large consumption occurs usually from June to September. The maximum day on the entirc system, 135,600,000 gallons, was on June 21, 1947, and within the city 104,789,000 gallons on June 18, 1945.

Meters and Service Connections.—On June 30, 1947, there were 138,178 service connections in use, all of which were metered. Large services for all purposes include 691 three-inch, 318 four-inch, 286 six-inch, 172 eight-inch, 8 twelve-inch, and 2 sixteen-inch; of these, 350 connections 4 to 12 inches in diameter serve automatic sprinkler systems. Controlling valves for large connections are set 18 inches from the main.

PRESSURES.—No recording pressure gages are permanently attached to the distribution system. Recording gages have been temporarily installed for brief periods since 1913 at a large number of hydrants in different parts of the city. Charts on file show considerable differences between day and night pressures in most parts of the city.

Fire department records show pressures at all hydrants. Readings from 323 hydrants well distributed throughout the city, taken during the making of fire flow tests and later by a National Board engineer in January and February 1948, are summarized in Table 3. As compared with October 1938, pressures in the entire city average the same, in the University Mound and College Hill services, 5 and 7 pounds lower and in the Sunset and Sunset Transmission services, 2 and 6 pounds higher.

DISTRIBUTION SYSTEM.—General.—Due to the wide range of elevation and uneven topography in the area supplied, distribution is in seventeen services, most of which have irregular limits with frequent interlacing of mains. The four largest and most important, which serve 75 per cent of the closely built area of the city, are

supplied by gravity from distributing reservoirs. Three services near the southern city limits are supplied directly from the supply mains. Five services at high elevation are supplied by pumping from the gravity services or supply mains; each has equalizing storage. Five services have pressures reduced by regulating valves or high friction losses in small pipes. Numerous emergency connections, many of which are of large size, are provided between adjacent services. For areas supplied, force and supply mains to each, and emergency connections, see accompanying map.

Table 3.—Pressure at Hydrants.

Service	No. of Readings	Pressure, Pounds per Sq. Inch., with Hydrant Outlets Closed		
		Avg.	Max.	Min.
University Mound Transmission	5	49	59	26
University Mound	97	55	68	19
College Hill	23	64	91	34
Sunset Transmission	54	67	129	14
Sunset	65	72	121	35
Lombard Street	8	56	79	31
Merced Manor	10	57	70	41
Stanford Heights	27	91	131	36
Presidio Heights	12	73	107	48
Forest Hill	6	90	115	37
Other Services	16	67	125	19
Congested Value District				
University Mound	19	56	64	40
College Hill	1	60	....	....
Sunset	5	74	87	58
Entire District	25	60	87	40
Entire City	323	66	131	14

University Mound Service.—The University Mound service supplies more than a fourth of the built-up area of the city, adjoining San Francisco Bay and lying below the 90-foot contour. It is by far the most important of the services, and includes the major portion of the congested value district, practically all of the industrial, warehouse and wharf districts, minor mercantile localities of high value, and residential sections, some of which are closely built with intermingled apartments. It is supplied by gravity from the two basins of the University Mound reservoir with Francisco Street reservoir as an emergency equalizer.

College Hill Service.—The College Hill service supplies about a tenth of the built-up area of the city lying west of University Mound service and having elevations ranging between 55 and 230. It includes a small part of the congested value district and two minor mercantile districts, but its occupancy is mostly closely built residential. It is supplied by gravity from College Hill reservoir.

Merced Manor Service.—This service supplies a small narrow area adjoining the Pacific ocean and below the 90-foot contour. It is mostly scattered residential with a few isolated buildings of larger size. It is supplied by gravity from the Merced Manor reservoir.

Sunset and Subsidiary Services.—The Sunset service supplies a third of the built-up area of the city. It is mostly in the northwestern part of the city with extensions to the east and southeast and lies beween elevations 50 and 330. It includes part of the congested value district, but is mostly closely built frame residential with intermingled apartments and minor mercantiles. It is regularly supplied by gravity from the Sunset reservoir and in emergency from Lake Honda. The Lombard Street and Potrero Heights reservoirs are equalizers on subdivisions of the main service.

Directly supplied from the conduits to Sunset reservoir and Lake Honda is the Sunset Transmission service which occupies an area of moderate extent in the southwestern and south-central parts of the city. It is residential in character, closely built in few places and has elevations ranging from 100 to 330.

Stanford Heights and Presidio Heights Services.—The Stanford Heights service supplies a moderate area of irregular shape, mostly on the hill sides near the geographic center of the city, but with a long extension to the southern city limits; it lies between elevations 265 and 500. It is almost entirely residential in character and is closely built in a few portions. It is regularly supplied by the Central pumping station, with the Stanford Heights reservoir and Clarendon Heights tank as equalizers.

Supplied from the Stanford Heights service through regulating valves is the Presidio Heights service, a small area on three hills in the northern part of the city. Elevations range from 185 to 350. It is mostly closely built high-value residential with numerous intermingled apartments. During periods of high consumption, supply to its northern extremities may be augmented by the Francisco Street pump with the Presidio Heights tank as an equalizer.

Forest Hill Service.—The Forest Hill service supplies a small area south and west of Lake Honda lying between elevations 525 and 710. Occupancy is mostly detached dwellings. It is supplied by the Lake Honda and Forest Hill pumping stations with the Forest Hill tanks as equalizers.

Main Arteries.—University Mound Service.—See accompanying map. From the University Mound reservoirs two supply mains extend into the distribution system. The older, a 44-inch

main, extends northerly about 1½ miles where it divides into branches, one, 24 inches in diameter, reducing to 22-inch, and the other, 37½ inches reducing successively to 36, 33 and 30 inches. These branches extend by different routes northeasterly about 3½ miles into the congested value district where they unite. Cross-connecting the two branches are two mains, a 16- and a 20-inch. The newer supply main has a total length of nearly 6 miles, passing through the congested value district and terminating at its northern limits in a 20-inch main; it reduces successively from 48 to 30 inches in diameter and is cross-connected to the older system by two 36-inch and numerous smaller connections.

In the central portion of the service 12- and 16-inch secondary feeders are numerous and are looped about mainly small areas within and near the congested value district. In the southeastern portion of the service, the looping is rather wide. From the congested value district, a 22-20-inch main, and a 16-inch main extend by different routes northwesterly about 2 miles to the Francisco Street reservoir; a 16-inch main with two 12-inch branches supplies the closely built residential district at the limit of the service.

College Hill Service.—From the College Hill reservoir, three supply mains extend into the distribution system. The older two are a 24-22-inch main and a 22-16-inch main which extend northerly along the east boundary of the service. Both were broken by the 1906 earthquake where they crossed a low, swampy tract on Valencia Street near Eighteenth Street; a detour, since constructed in the 24-inch line around this infirm ground, and a replacement of the second line, are respectively partly and entirely of 16-inch pipe. The newest supply main, 36-30 inches in diameter, extends to near the center of the service. It is cross-connected to the older mains by one 20- and two 16-inch mains, the first having emergency connections from the University Mound and Sunset services. The above mains, together with 12- and 16-inch secondary feeders, form a well looped system in the central portion of the service. Two long extensions, one into the congested value district and the other at the extreme southeastern part of the service, are supplied through single 16-inch mains and a small detached area east of the main service by a long loop of 12- and 16-inch pipe.

Merced Manor Service.—A 20-inch main extends nearly 2 miles from the Merced Manor reservoir well into the service. It has an emergency connection from a 30-inch Sunset Transmission service main near the reservoir. Other than the above 20-inch, the service has no mains larger than 8-inch.

Sunset and Subsidiary Services.—A 60-inch supply main extends north and east from Sunset reservoir about 1¾ miles where it connects with 30- and 36-inch mains from Lake Honda and its by-pass. From this point, three mains variously 22 to 36 inches in diameter, extend three miles northeasterly. These mains, together with numerous branches and cross-connections of large size, form a strong and well-looped system in the greater part of the service. A single main, partly 16- and partly 12-inch, extends into the congested value district. The southeastern part of the service is supplied through two mains, 16 and 24 inches in diameter, from which several long branches of 12- to 20-inch pipe extend to the service limits. In emergency the service may be supplied by Lake Honda.

The Lombard Street service has a 12-inch loop of moderate extent with two short 12-inch branches. A 30-inch main, branching from the 54-inch San Andreas pipe line just south of the city limits, extends through the Sunset Transmission service. It supplies a number of 12- and 16-inch mains, most of which are looped about large areas.

Stanford Heights and Presidio Heights Services.—A 24-inch force main, regularly used, extends 1¾ miles from the Central pumping station to the Stanford Heights reservoir. Reservoir and Clarendon tank are connected by 1¾ miles of 23½- and 24-inch pipe. From the reservoir a main, mostly 20-inch, with several connections to the 24-inch, extends northerly 4 miles to regulating valves at two points supplying the Presidio Heights service. A 12-inch, partly paralleling the 24- and 20-inch mains, and two single 12-inch secondary feeders extend through the northeastern part of the service. From the reservoir, a 16-12-inch main, 4½ miles long, has been laid over a circuitous route through the southern part of the service; it has two 12-inch branches and a 20-16 branch, 3 miles long, supplies territory west of Twin Peaks.

The Presidio Heights service is supplied through regulating valves from the Stanford Heights service. The principal and auxiliary regulators, one mile apart are connected by a 12-inch loop laid through the western part of the service. From the principal regulating valves three mains, a 12-inch, a 20-22-inch and a 24-inch recently laid, extend easterly to the central part of the Presidio Heights service and a 16-inch, reducing to 12-inch, continues to the eastern limits. The Presidio Heights tank which is lower than the service water plane, is kept filled for emergency use and is connected by 12-inch pipes. A 16-inch force main from the Francisco Street pump, used during periods of peak consumption to sustain pressures, extends into the eastern limits of the service.

Forest Hill Service.—From the Forest Hill pumping station a 6-inch force main extends into the distribution system. From the Forest Hill

tanks a 12-inch connection, 600 feet long, supplies a short 12-inch branch extending north and a 16-12-inch branch 1½ miles southeasterly.

Minor Distributors.—It is the general policy to reserve main arteries for the supply of secondary feeders and to connect minor distributors only to the latter. In the congested value district, of a total of 167,000 feet of pipe essential to the supply of hydrants, 4 per cent is 4-inch, 20 per cent is 6-inch, 38 per cent is 8- and 10-inch, 30 per cent is 12- and 16-inch and 8 per cent is 20- to 30-inch.

In other parts of the city, as shown by Table 4, minor distributors are mostly 6- and 8-inch with a moderate amount of 4-inch. Much of the 4-inch pipe is used solely to distribute domestic supply, only 58 miles being essential to hydrant supply. Gridironing is good in closely built parts of the city. The average length of 4- and 6-inch mains between cross-connections on the long side of closely built blocks is 580 feet. Because of the uneven topography and numerous services, dead ends are fairly numerous in all parts of the city; including those at service limits, dead ends of 4- and 6-inch pipe supplying hydrants amount to 36.4 miles. In addition to the pipe shown in Table 4, 123 miles of smaller pipe, principally 2-inch, is used to distribute domestic supply.

PIPES.—Length and Age.—See Table 4. The average age of steel and wrought iron pipe in service is 24 years; 17 per cent, including the older supply mains from the University Mound and College Hill reservoirs, is over 56 years old. The average age of cast-iron pipe is 39 years; 32 per cent of the total has been laid within the past 16 years and 30 per cent is 60 years old. It is present practice to use welded steel for mains 20 inches and larger in diameter.

Condition and Cover.—The older iron pipes are considerably affected by tuberculation and incrustation; tests show the carrying capacity of 8-inch pipe is reduced one per cent a year. The capacity of wrought iron pipes has diminished but slightly with age. Mains are flushed on request, but there is no systematic flushing of the pipe system; discharges during fire flow tests showed considerable sediment. No cast-iron mains have been affected by electrolysis. Pipes are laid with a cover of 2½ feet. In several places where fills have subsequently been made, cover is as much as 8 to 12 feet. The 44-inch supply main from University Mound reservoir crosses a creek and a swamp on concrete piers. Other stream crossings are effected by carrying pipes on wooden trestles or by laying them in stream bed. A considerable part of the system, including some arteries, is on soft ground subject to earthquake shocks; in 1906, fully 300 ruptures occurred in the pipe system.

Table 4.—Pipes in Distribution System, January 1, 1948*

Size, Inches	Length, Miles			Per Cent of Total	Net Increase Since June 30, 1938 Miles,
	Steel Wrought Iron Transite	Cast Iron	Total		
4	0.91	95.31	96.22	10.43	3.18
6	1.65	328.63	330.28	35.82	48.41
8	1.52	289.15	290.67	31.52	41.11
10	.....	2.02	2.02	0.22	0.72
12	1.33	80.84	82.17	8.91	7.01
16	4.85	48.83	53.68	5.82	3.13
20	12.45	4.29	16.74	1.82	0.00
22	4.61	3.61	8.22	0.89	0.00
24	9.56	9.88	19.44	2.11	2.83
30	5.11	1.16	6.27	0.68	0.00
33	0.45	.....	0.45	0.05	0.00
36	7.74	.....	7.74	0.84	0.00
37½..	1.68	.....	1.68	0.18	0.00
44	4.35	.....	4.35	0.47	1.54
48	2.18	.....	2.18	0.24	0.00
Totals	58.39	863.72	922.11	100.00	107.93

* Including 22.15 miles private mains supplying hydrants.

Specifications.—Cast-iron pipe laid before 1910, including about 51 per cent of that now in service, was purchased under specifications which prescribed a deeper bell, thicker wall and better quality of iron than required by the American Water Works Association, and included a rigid foundry inspection. Since that date, Class B pipe, American Water Works specifications or Class 150, centrifugally cast pipe, have been used with inspection upon delivery. Joints in cast-iron pipes are mostly of cement, with some lead and a small amount of mineral lead. Recently laid steel lines are welded. New mains are tested under working pressure before being placed in service.

GATE VALVES.—Number and Type.—On January 1, 1948, 9,404 gate valves, 4-inch and larger, were in service. Most valves are of special design, of heavy cast-iron, with bronze stem and faces; others are Rensselaer or Kennedy. Valves open to the right with the exception of 12, the direction of opening being shown in the gate books provided for field use. With a few exceptions where pressures are low, valves 16 inches and larger are geared and set in vaults having cast-iron covers. Other valves are operated through extension boxes. Valves on the 54-inch supply line are provided with by-passes. In many cases valves are a size smaller than the mains in which they are set. Pocket sized sectional maps

covering the entire city have drawings of complicated intersections and detailed measurements to all valves. Controlling valves on supply lines and at pumping stations and reservoirs generally have rising stems.

Location and Spacing.—Valves are generally located at street intersections on or near property lines. The average length of main which would be shut off in consequence of a single break in the congested value district is 1,020 feet, with 23 sections out of 198 exceeding 2,000 feet, and a maximum of 5,890 feet; large sections are mostly south of Market Street. In two representative residential districts, one of 346 acres, northwest of the congested value district and the other of 608 acres, in the western part of the city, the average shut-off section is 1,410 feet in length, with 12 sections out of 161 in excess of 3,000 feet, and a maximum of 4,900 feet.

Inspection and Condition.—Valves are not regularly inspected and are rarely operated except in connection with repairs or new work. An inspection of 43 valves, 6 to 36 inches in size, was made by an engineer of the National Board of Fire Underwriters in February 1948; all were readily located and operated easily; few minor defects were noted.

Closing of valves.—Valves separating the services are normally closed and are operated only in emergency to augment the supply in areas where there are excessive drafts. When the closing of valves affects the hydrant supply, the operator at fire alarm headquarters is notified and again when service is restored.

HYDRANTS.—Number and Type.—Fire department records show that on April 29, 1948, 6,854 hydrants were in service on the domestic water system. Hydrants are of California type, of local makes, and have a tapered base increasing from the size of the branch to the size of the barrel, which is generally 6 to 6¼ inches. Barrels are filled with water and there are valves on each outlet opening uniformly in a counter-clockwise direction. All but 20 hydrants have two 3-inch outlets; the others have either one or two 2½-inch outlets, or one 3-inch and one 2½-inch outlets. All connections from mains are gated; about 3,680 are 5-inch and the others 4-inch. In addition, about 300 hydrants are on mains of housing projects, Army and Marine Corps Depots, parks and institutions and supplied through meters. Three of these have some equalizing storage beyond meters but except for Hunter's Point housing this is insufficient for hydrant supply. Hydrants are of post type and various makes; some have foot valves and all have two 3-inch outlets.

How Located.—In high value districts one to three hydrants are located at street intersections, with one or more intermediate hydrants, depending on the length of block and character of district. In closely built residential districts there are usually two hydrants at street intersections and in areas of detached dwellings, one hydrant. New hydrants are installed as recommended by the fire department.

Inspection and Condition.—Hydrants are inspected by the maintenance force of the high pressure system. The city is divided into 10 districts and one man assigned to each. Hydrants in important districts are inspected several times a year, and others annually, the inspection extending to the valve in the connection from the main and including operating, flushing and oiling; records are kept of inspections and repairs. Of the 594 hydrants used by engineers of the National Board of Fire Underwriters during this inspection, the great majority were in excellent condition.

Distribution.—In the congested value district, the average area served by hydrants on the domestic system is 51,000 square feet, which figure is reduced to 33,000 square feet by including high pressure hydrants. Outside the congested value district, the average area served by all hydrants is 117,000 square feet. Of the 378 hydrants within, and 151 adjacent to, the congested value district, 297 have 4-inch and 232 have 5-inch connections from the main; all have two 3-inch outlets.

Use by Street Department and Others.—Hydrants are used indiscriminately for filling sprinkling tanks and street and sewer flushing. Hydrants are occasionally used by contractors, who must obtain a permit from the water department, countersigned by the fire department, and install a meter on the outlet. Little trouble is experienced by this general use.

FIRE CISTERNS.—There are 116 fire cisterns in service in the northern and eastern portions of the city, a net decrease of 10 since 1939. They have no connections from the water system but are filled from hydrants by the fire department and are inspected monthly. Total capacity is 8,790,000 gallons. Those built within the past 40 years are of reinforced concrete construction of very substantial design; 1 contains 250,000 gallons, 106 contain 75,000 gallons each, and 2 are of smaller size. The remaining 7 are of brick with an average capacity of 69,000 gallons. Two pumpers may be placed to draft from each, access being provided through manholes.

FIRE FLOW TESTS.—See Table 5 for results of tests and accompanying map for location of groups. Fifty-nine were made at the same or approximately the same locations as previous tests, and eleven were made in new localities which had become of importance because of the

TABLE 5.—FIRE FLOW TESTS.

District, Number and Location of Group *	Service	Elevation	Discharge, Gallons per Minute							Pressure, Pounds		Quantity at 20 lbs.	
			Individual Hydrants						Total of Group	Hydrants Closed	Hydrants Open	Required	Available
CV 1. Sansome and Jackson Sts.	UM	4	560	650	860	880	1030	1120	5100	65	59	†	15000‡
CV 2. Kearny and Pine Sts.	UM	39	430	580	670	690	780	860	4010	50	43	†	8800‡
CV 3. First and Minna Sts.	UM	6	610	690	750	830	860	900	4640	64	47	†	7700‡
CV 4. Fifth and Stevenson Sts.	UM	22	710	770	850	1010			3340	58	52	†	9000‡
CV 5. Sutter and Hyde Sts.	SU	160	670	720	760	770	890	1080	4890	76	54	†	8100‡
Ind. 6. North Point and Hyde Sts.	UM	57	540	690	700	960			2890	41	29	4500	3900‡
Ind. 7. Taylor and Beach Sts.	UM	1	700	740	780	1030			3250	66	52	4000	6200‡
Ind. 8. Eighth and Harrison Sts.	UM	12	640	820	910	1000			3370	64	60	5000	12300‡
Ind. 9. Third and Sixteenth Sts.	UM	3	680	710	880	960			3230	64	58	5000	9500
Ind. 10. Twenty-second and Illinois Sts.	UM	26	560	760	770	780			2870	52	36	5000	4200‡
Ind. 11. Third St. and Evans Ave.	UM	2	710	740	740	960			3150	67	58	5000	7700‡
Ind. 12. Third St. and Paul Ave.	UM	23	430	570	580	600			2180	54	19	3000	2100
Ind. 13. Marin St. and Evans Ave.	UM	19	1010	1070	1300	1450			4830	59	53	6000	13300‡
Ind. 14. Dorman St. and Barneveld Ave.	UM	6	710	760	910	1090			3470	66	55	4000	7500
Ind. 15. Sixth and Hooper Sts.	UM	0	820	920	970	1030			3740	66	54	6000	7700
Ind. 16. Seventeenth and Vermont Sts.	CH	44	230	460	680				1370	80	26	4000	1400‡
WH 17. Third and Berry Sts.	UM	0	710	780	830	1020			3340	68	54	6000	6500‡
WH 18. Main St. and Embarcadero	UM	1	720	760	930	940			3350	67	46	6000	5200‡
WH 19. Sansome and Lombard Sts.	UM	0	810	880	950	1040			3680	66	55	6000	8000‡
WH 20. Fifth and Townsend Sts.	UM	0	630	820	930	960			3340	68	51	5000	5800‡
AU 21. Van Ness Ave. and Sacramento St.	SU	180	700	740	760	940			3140	67	54	6000	6300‡
MM 22. Geary and Fillmore Sts.	CH	117	620	630	700	730			2680	52	37	5000	4000‡
MM 23. McAllister and Hyde Sts.	UM	40	270	280	370	380			1300	47	12	8000	1100‡
MM 24. Third and Folsom Sts.	UM	15	630	770	870	970			3240	61	55	6000	9100‡
MM 25. Fourteenth and Valencia Sts.	CH	30	990	1000	1040	1120			4150	91	84	5000	14500‡
MM 26. Eighteenth and Mission Sts.	UM	23	600	650	670	760			2680	59	35	5000	3500‡
MM 27. Twenty-fourth and Mission Sts.	UM	62	520	540	630	660			2350	42	25	5000	2700‡
MM & Res. 28. Scott and Chestnut Sts.	UM	10	540	570	640	660			2410	51	23	5000	2500‡
MM & Res. 29. Ninth Ave. and Irving St.	SU	254	580	670	770	870			2890	51	49	3500	12700‡
MM & Res. 30. Twentieth Ave. and Irving St.	SU	211	610	790	800	880			3080	68	64	3500	11800‡
MM & Res. 31. Twentieth Ave. and Geary Blvd.	SU	134	720	770	900	1110			3500	99	90	4000	11300
MM & Res. 32. Seventh Ave. and Clement St.	SU	175	540	880	880	1030			3330	79	71	4000	9800‡
MM & Res. 33. Twenty-first Ave. & Taraval St.	SUT	302	610	630					1240	33	29	3000	2300
MM & Res. 34. Capitol and Ocean Aves.	SUT	253	650	740	740	880			3010	59	53	3000	8300
Ins. & Res. 35. Excelsior Ave. and Lisbon St.	SUT	217	770	830	900	920			3420	69	54	3000	6500
Ins. & Res. 36. Silver Ave. and Yale St.	SUT	239	410	450	570				1430	56	13	3000	1300
Ins. & Res. 37. Second and Parnassus Aves.	SH	392	540	590	700				1830	88	30	4000	2000‡
Ins. & Res. 38. Nineteenth Ave. & Lawton St.	SH	319	920	1150	1160				3230	125	103	3500	7500
Ins. & Res. 39. Thirtieth Ave. and Lawton St.	SU	235	600	630	780	790			2800	56	42	3000	4600
Ins. & Res. 40. Twenty-ninth Ave. & Vicente St	SUT	153	730	870	1090				2690	96	93	3000	15000
Apt. 41. Serrano and Arballo Drs.	SUT	107	780	940	990	1140			3850	121	69	3000	5500
Apt. & Res. 42. Page and Pierce Sts.	SU	155	730	820	850	890			3290	90	78	4000	8500‡

TABLE 5.—FIRE FLOW TESTS.—Continued

District, Number and Location of Group *	Service	Elevation	Discharge, Gallons per Minute: Individual Hydrants				Discharge, Gallons per Minute: Total of Group	Pressure, Pounds: Hydrants Closed	Pressure, Pounds: Hydrants Open	Quantity at 20 lbs.: Required	Quantity at 20 lbs.: Available
Apt. & Res. 43. Page and Cole Sts.	SU	253	680	710	840	860	3090	49	46	4000	10500‡
Apt. & Res. 44. Clay and Laurel Sts.	PH	288	480	570	680	690	2420	57	33	4500	3000‡
Apt. & Res. 45. Broderick and Jefferson Sts.	UM	3	470	560	570	640	2240	52	23	4500	2400‡
Apt. & Res. 46. Fillmore St. and Broadway	SU	236	550	570	630	750	2500	39	23	4500	2700‡
Apt. & Res. 47. Washington & Buchanan Sts.	PH	272	450	510	530	780	2270	62	31	4500	2700‡
Apt. & Res. 48. Leavenworth and Green Sts.	PH	295	200	510			710	61	34	4000	900‡
Apt. & Res. 49. California and Taylor Sts.	PH	278	510	580	680	730	2500	75	37	6000	3000‡
Housing 50. South Ridge and Hilltop Rds.	HP	230	560	600			1160	48	20	3000	1200
Housing 51. Blanken Ave. & Candlestick Rd.	UMT	18	410	450			860	59	49	3000	1800
Housing 52. Blythdale and Santos Drs.	SUT	110	490	720	800	840	2850	118	39	3000	3200
CBF Res. 53. Grant Ave. and Greenwich St.	LS	153	350	770	820		1940	58	33	4000	2400‡
CBF Res. 54. Greenwich and Pierce Sts.	UM	30	280	400	460	510	1650	40	18	4000	1600‡
CBF Res. 55. Fifth Ave. and Balboa St.	SU	182	670	700	960	990	3320	77	71	3500	11200‡
CBF Res. 56. Thirty-sixth Ave. & Balboa St.	SU	183	630	670	1000	1080	3380	78	67	3500	8300
CBF Res. 57. Corbett Ave. and Danvers St.	SH	312	620	880	940	1040	3480	123	73	3000	5100‡
CBF Res. 58. Twenty-second and Castro Sts.	SH	313	240	450	580	630	1900	123	27	3500	2000‡
CBF Res. 59. Nineteenth and Missouri Sts.	POT	154	300	400	600	690	1990	65	30	3000	2300
CBF Res. 60. Newton and Morse Sts.	SUT	244	580	600	670	890	2740	58	37	2500	3800
CBF Res. 61. 47th Ave. and Quintara St.	MM	16	560	680	700	710	2650	66	30	3000	3000
CBF Res. 62. Forty-fifth Ave. and Irving St.	MM	51	230	350	430	560	1570	50	12	3000	1400
CBF Res. 63. Grafton Ave. and Bright St.	SUT	274	480	480	530	560	2050	48	44	2500	5900
DET Res. 64. Raymond Ave. and Delta St.	WA	107	330	490	550	700	2070	125	26	2500	2100
DET Res. 65. Hearst Ave. and Edna St.	SUT	265	330	450	840	890	2510	50	28	3000	3000
DET Res. 66. Plymouth Ave. and Broad St.	SUT	299	480	640	640	690	2450	37	28	2500	3500
DET Res. 67. Urbano Dr. and Moncada Way	SUT	213	720	880	990		2590	74	53	2500	4300
DET Res. 68. St. Francis Blvd. & San Benito Way	SH	350	560	640			1200	110	23	2500	1200
DET Res. 69. Eighth Ave. and Pacheco St.	FH	542	670	790	900		2360	111	83	2500	4500
DET Res. 70. 26th Ave. and Scenic Way	SU	90	730	1140	1250		3120	122	91	2500	5900

* Location of Groups Shown on Accompanying Map by Corresponding Numbers. Districts indicated as follows: CV-Congested Value Ind.-Industrial WH-Warehouse MM-Minor Mercantile Res.-Residential Ins.-Institutional Apt.-Apartment CBF Res.-Closely built frame Residential DET Res.-Detached Residential.
† 12,000 gallons about any block, with a main feeder capacity of 18,000 gallons. AU—Automobile
‡ Additional water available from separate high pressure fire system.
UM—University Mound SH—Stanford Heights LS—Lombard Street
SU—Sunset Reservoir PH—Presidio Heights POT—Potrero Heights
CH—College Hill HP—Housing Pump Service MM—Merced Manor
SUT—Sunset Transmission UMT—University Mound Transmission WA—Wilde Avenue Reservoir
FH—Forest Hill

city's growth. Tests were made on January 18th to 20th, 1948, between 7:43 A.M. and 2:35 P.M. Tests 1 to 8, 17 to 19, 21 to 27, 48, 49 and 53 were made on Sunday morning with consumption for the day 13 per cent less than the average rate; the remaining tests were made on week days with consumption at the average rate. Reservoirs and tanks were practically full and operation of pumping stations was normal for the time of year.

RECENT AND CONTEMPLATED IMPROVEMENTS.—Since the National Board of Fire Underwriters report of March 1939, the Irvington pumping station has been constructed to introduce water from Alameda subsurface sources into the Hetch Hetchy aqueduct. Pumps at Millbrae have been removed and a new station at Baden makes Crystal Springs water available to services previously dependent on San Andreas supply. A third San Andreas reservoir outlet, with connections to the other outlets, has been provided for a future 60-inch transmission line. The first section of this line, soon to be put into service, extends from a 44-inch cross-connection to the 54-inch San Andreas line 1½ miles south of the city to Sunset Reservoir, skirting Lake Merced en route. This 60-inch artery is to be extended to the new San Andreas outlet within the next few years.

Black Point, Clarendon Heights, Precita Valley and Sunset pumping stations, formerly in reserve, have been dismantled, as have wells supplying the latter. A major city pumping station, Alemany has been built near the University Mound reservoir, from which it takes supply and delivers through a new 44-inch force main to the 44- 36-inch cross-town line to College Hill reservoir, providing for the increased consumption of this service. In emergency it may supply the 54-inch San Andreas-Sunset transmission line. Two motor-driven pumps have been installed at Central pumping station, increasing capacity and flexibility of this plant. Former Clay Street tank has been moved to provide greater storage on the Keith service. A second tank adjacent to the Keith tank adds storage available to the Hunter's Point housing area. A second Forest Hill tank has been installed and one replacing the Potrero Heights tank is projected for the immediate future. Twin Peaks tank has been provided to supply a small, sparsely built area at high elevation. Lake Honda is kept filled and in reserve. Sunset reservoir now supplies the former Lake Honda service at slightly greater pressure. Forest Hill pumps are now supplied by the small, automatic Lake Honda booster station taking suction from a 30-inch Sunset artery. Sutro reservoir, with capacity of 32,000,000 gallons at elevation 500, is partially completed and will supply a new service intermediate between Stanford Heights and Sunset.

The distribution system has been increased by 107 miles of pipe most of which consists of ordinary extensions of 6- and 8-inch pipe. Over 14 miles are 12 to 44 inches in diameter and include several main arteries and secondary feeders. The number of gate valves 4 inches and larger has been increased by 1,476, an increase of 18.6 per cent, materially reducing the length of pipes in gated sections; 578 hydrants have been added to the city mains and 300 on private mains supplied by the system, an increase of 14 per cent.

Contemplated improvements in the supply works in addition to those already mentioned include the paralleling of the San Joaquin pipe line with a line of like capacity by 1950, and installation of a 72-inch conduit, with a capacity of 76,000,000 gallons a day, from the Irvington portal to Pulgas tunnel by a land route south of San Francisco bay. Also planned is a pumping station at Lake Merced with connections to the new 60-inch San Andreas-Sunset line and to Stanford Heights reservoir. This station will replace the present Lake Merced plant, take over the duty of the Central pump station and make it possible to supply Crystal Springs or Lake Merced water to several city services.

CONCLUSIONS.—Organization.—The water department is well organized with competent and experienced officials and is mainly under civil service regulations. Records are generally complete, accessible and safely filed. Fire alarms are received and emergency operations are good except that response is made to second alarms only.

Supply Works. — With the Hetch Hetchy source, the city's sources of supply are amply sufficient. The number of gravity sources, combined with the ability to use well supplies as required, give the supply works a high degree of reliability. Storage capacity provided within 12 miles of the city is sufficient to supply the entire system for ten months. Dams and important structural features of the supply works are well designed and permanently built. Pumping stations are not fireproof but important ones are unexposed and protection provided is fair; equipment is of satisfactory capacity. Conduits from the peninsula reservoirs to the city are sufficient in number and capacity, but two have reached an age when their condition must be carefully watched. Storage within the city is nearly four days maximum consumption.

Portions of the city at high elevations are generally supplied by single pumping stations with very small equalizing storage. Although maintenance is good, some of the stations are severely exposed, and generally they have internal hazards and only moderate reserve equipment.

Consumption.—Consumption is moderately low because of the universal use of meters.

Pressures.—Pressures are fair and are sufficient for automatic sprinkler supply in low buildings. They are fairly well sustained under fire draft and maximum consumption conditions.

Protection.—The primary source of fire protection to the congested value district is the separate high pressure fire system which can furnish full fire supply to all parts of the district at high pressures. In addition, the domestic system can furnish fair to good quantities for large single fires. Similar conditions exist in other parts of the city where most high value districts are protected by the high pressure system. Outside this area, 20 out of 28 tests made under average conditions showed adequate quantities for fire engine supply. Of the 8 unsatisfactory tests, the deficiency was considerable or serious in 5, Groups 48, 54 and 58 (Table 5), being in residential districts and Groups 50 and 51 being in Government Housing Projects having private mains. Fifty-five per cent of the tests repeated showed lesser quantities of water than were obtained in 1938.

Mains.—In each of the three most important services, the distribution system has the disadvantage of being supplied from a single point; this fact is compensated for in part by duplication of supply mains and numerous large emergency connections between adjacent services. Several large areas are served by single main arteries; where mains are in duplicate, they are frequently laid either in the same street or in adjacent streets, detracting from their efficiency. The lack of connections between main arteries and the many smaller mains which are available affects fire protection adversely. The system of secondary feeders is good in the central part of the University Mound service but is incomplete or entirely lacking in many other parts of the city.

Minor distributors used for hydrant supply in the congested value district and other parts of the city include a considerable amount of small pipe. Gridironing is good. Dead ends are fairly numerous because of the uneven topography and many services.

Pipes are generally in sound condition, although two wrought iron supply mains are over 47 years old and the carrying capacity of cast-iron pipes has been reduced through age. Where mains are in made ground the effect of earthquake shocks is especially pronounced and decreases the reliability of the pipe system.

Gate Valves.—Although spacing has been improved since 1939, the system is still inadequately provided with gate valves; the necessity of having to close a large number of valves to shut off a single section causes unnecessary delay, and when such a section is cut out, it leaves a large area without fire protection. Although valves inspected were in good condition, their importance is sufficient to warrant regular inspections.

Hydrants.—Hydrants receive excellent care, being regularly inspected and maintained in good condition. About 50 per cent are small or are set on mains too small to furnish a satisfactory supply. Distribution in the congested value district is good and other districts, fair to good.

OCEAN SALT WATER COMPANY

A private company, the greater part of whose works were built in 1893, supplies salt water to four clubs, the Steinhart Aquarium and two beach concessions, and furnishes public fire protection from 51 hydrants. W. J. Fletcher, 524 Post Street, is president. The supply is pumped from the Pacific Ocean to the distribution system, with equalizing and distributing reservoir.

The pumping plant is adjacent to the beach on Great Highway south of Balboa Street. Pumps take suction through a 16-inch flanged cast-iron line about 700 feet long, supported on a pier over the water, with 10-inch inlet. The intake is uncovered by tidal stages of less than 1.5 feet and by troughs of waves when less than 2.4 feet. The station contains a 2,000,000-gallon, horizontal, double-acting, flywheel pump and a 500,000-gallon, duplex, tandem pump; both were originally steam-driven but now are geared to 200- and 50-h.p. electric motors. Operation is in one shift, the station usually being run six to eight hours a day, six days a week.

Station is of brick and frame construction with much combustible material; pump room floor is about 20 feet below grade. Station is severely exposed on the north and south by low frame mercantiles and on the east by a roller coaster. Protection is furnished by 1-quart and 2½-gallon extinguishers, three 1½-inch risers with hose attached, perforated pipe with circulating nozzles on roof, and 6 salt and 3 fresh water hydrants within 500 feet.

The reservoir, at Geary and Josephine Streets. is filled from the station through 19,500 feet of 16-inch cast-iron pipe. It is mainly in excavation and, with water at elevation 280, contains 4,470,000 gallons. Four swimming pools at different locations, holding from 100,000 to 350,000 gallons, have connections, mostly of small size, at which pumpers may draft. In emergency the system may be supplied from the municipal high pressure fire system by installing a 3-inch connection at Bush and Larkin Streets.

Distribution to hydrants east of the reservoir is through 4,950 feet of 14-inch and 4,900 feet of 12-inch pipe. Pipes are cast-iron and in sound condition; most are 54 years old and show a decrease in carrying capacity. Hydrants are of post type, furnished by the city and maintained by the fire department. Practically all are supplied directly from the 16-inch main. One at the beach is the same as used on the separate high pressure

fire system; the others are of California type with 6-inch barrels; 23 have 5-inch connections from main, 4 having one 4½- and one 3-inch outlets, and 19 two 3-inch outlets; 27 have 4-inch connections and one 3-inch outlet. Static pressures at the beach are 115 pounds; along Geary Street they range from 5 to 35 pounds.

SEPARATE HIGH PRESSURE FIRE SYSTEM

ORGANIZATION.—The system was placed in service in 1913. Operation and maintenance are under the supervision of the board of fire commissioners and of the chief of the fire department and in direct charge of the superintendent of equipment, R. D. Keeley, a technical graduate. There are 2 chief engineers, 5 engineers and 7 firemen at the pumping stations; 5 operators at the tanks; 1 foreman and 13 gate men, who also maintain hydrants; and 1 caulker and 3 laborers; all are under civil service regulations.

The maintenance force ordinarily works in one shift of 8 hours, reporting hourly, but is subject to call at all times. The superintendent or foreman and at least 2 gatemen respond to third alarm fires. A large number of automobile trucks properly equipped with suitable maps and tools are provided for emergency use; eleven are equipped to operate valves mechanically. All fire companies, except booster tank companies, carry gate wrenches. Alarms of fire are received on gongs at the pumping stations and tanks and in the residences of the superintendent, foreman and gatemen.

GENERAL OUTLINE OF SYSTEM.—See accompanying map. A system of cast-iron mains, used only for hydrant supply, furnishes protection to an area of 14.2 square miles in the northeastern part of the city including the entire congested value district, practically all important mercantile and industrial districts and many closely built frame residential districts. The system is normally supplied by gravity from two tanks at moderate elevations; a storage reservoir at high elevation southwest of the congested value district is available to replenish tanks or to increase pressures in the entire system. Two pumping stations, northwest and southeast of the congested value district, supplied from San Francisco Bay, are maintained in readiness for emergency use. Six manifolds are provided through which fire boats can pump into the system.

FRESH WATER RESERVOIR AND TANKS. — General. — Tanks are filled through connections from the domestic water system. The reservoir is filled from Ashbury tank by two 800-gallon electrically operated centrifugal pumps discharging into either of two 20-inch lines; pumpage is measured. Operators are on duty at all times at tanks and during the day at the reservoir.

Twin Peaks Reservoir.—Located near the intersection of Twentieth and Cole Streets, extended, 2½ miles southwest of the congested value district. The reservoir is elliptical in shape, on rock foundation, lined with concrete slabs having expansion joints, and, with water 26 feet deep at elevation 758.5, contains 11,000,000 gallons. It is divided into two equal parts by a buttressed wall of reinforced concrete. Outlet is through two 20-inch pipes to Ashbury tank.

Ashbury Tank.—Located on Ashbury Street between Seventeenth and Eighteenth Streets, 2,000 feet northeast of the reservoir. It is built of riveted steel plates on a reinforced concrete base and has a wooden roof; with water 29 feet deep at elevation 493.5, it contains 500,000 gallons. It is in good condition. Discharge is through three 18-inch pipes. Controlling valves are so arranged that the tank may be by-passed and the system supplied directly from the reservoir.

Jones Street Tank.—Located on Jones Street between Sacramento and Clay Streets, ¼ mile outside the congested value district. Tank is of reinforced concrete with tile covered roof, in good condition, and, with water 36 feet deep at elevation 369, contains 750,000 gallons. It may be replenished from the reservoir or Ashbury tank through two mains, mostly 18 inches in diameter. Discharge is through two 18-inch pipes. Controlling valves are so arranged that the tank may be by-passed and the system supplied directly from Ashbury tank or the reservoir.

SALT WATER PUMPING STATIONS.— General.—Two pumping stations, located on opposite sides of the distribution system, are maintained to pump from San Francisco Bay in emergency. At both stations, each pump takes its supply through an independent suction line from a 5-foot concrete tunnel beneath the station; maximum lift is 15 feet. Discharge is through two 20-inch pipes which extend into the system by different routes.

One battery of 2 boilers is kept under working pressure in each station and all boilers can be brought to working condition in about 35 minutes. Three boiler feed pumps are provided; two are sufficient to operate each station. Fuel oil tanks are kept practically full. Oil pumps are in duplicate. Each station can generate its own lighting current. Both stations are operated at full capacity for an hour or two each quarter year. Operation of stations is in 3 shifts; at least 2 men are constantly on duty in each station and off-shifts respond on call for serious fires. Internal hazards are well cared for.

Station 1.—At Second and Townsend Streets, 1½ miles southeast of the congested value district. The two discharge mains lead from opposite ends of a loop which is so gated a single break may put 2 pumps out of service. Steam piping is in a well gated loop in which a single break may affect the operation of only one pump or battery of boilers. Oil piping is so arranged that in case of accident to the oil pump discharges, supply to the burners could be furnished through the returns.

Equipment.—Four Byron Jackson, 4-stage, turbine pumps directly connected to 750-h.p., Curtis, horizontal, non-condensing, steam turbines can each deliver 3,000 gallons a minute against a head of 300 pounds. Eight 350-h.p., Babcock and Wilcox boilers are installed in 4 batteries. Each battery has an independent reinforced concrete stack 90 feet high and 68 inches in diameter. Six boilers are required to operate the plant. Space is provided for 2 additional pumps and 2 batteries of boilers.

Six concrete tanks beneath the station, having a total capacity of 1,000,000 gallons, are kept filled with treated water for boiler use. Duplicate pumps are provided to raise feed water from tanks to heaters. Five underground tanks having a total capacity of 98,000 gallons of fuel oil are outside the station. It is estimated the station could be operated continuously for 96 hours without replenishment to its oil or feed water supply.

Construction.—The station is a high, 1-story, steel frame building with reinforced concrete walls and roof, covering 13,600 square feet, and is especially designed to resist earthquake shocks and exposure fires. No woodwork in the construction; structural steel roof-members are without fireproofing. Windows are of wired glass in metal frames; all exterior openings are protected by outside sliding steel shutters, operated from the inside. Floor level is about 10 feet below street grade. The station is moderately exposed on all sides across streets or alleys by mercantile or warehouse buildings, mainly of brick construction. Two 5-gallon extinguishers are installed.

Station 2.—Just west of the foot of Van Ness Avenue, in Fort Mason, a military reservation, 1½ miles northwest of the congested value district. The two discharge mains lead from opposite ends of a header, which extends the length of the station, and is so gated a single break may put 2 pumps out of service. Two pumps may operate in series with the other two, thereby doubling the pressure for one-half the quantity delivered. Steam piping is looped only through a connection with the line supplying the auxiliaries and a single break may put 2 pumps out of service. The oil supply to each burner is dependent upon a single line.

Equipment.—Four Byron Jackson pumps similar to those in Station 1 and six 466-h.p. B & W Stirling water tube boilers, set in 3 batteries, are provided. One reinforced concrete stack serves all. Three generators supplying electric current to Fort Mason are on station floor. Two boilers can operate one pump and the electric load, and 4 boilers, the entire station.

Two 50,000-gallon tanks on hill outside station have connections from the domestic water system and supply feed water to heaters; emergency supply can be obtained from the Fort Mason system. Three underground fuel oil tanks have a total capacity of 42,000 gallons.

Construction.—The station has the same structural features as Station 1. It covers 8,925 square feet and is unexposed. Fire protection is furnished by several 1-quart and 2½-gallon extinguishers and by one standpipe with 150 feet of 1½-inch hose attached.

CONSUMPTION.—The system is used solely for supply to hydrants and the entire carrying capacity of the mains is available for fire protection. Leakage is small, indicating thorough construction and efficient maintenance of the pipe system.

PRESSURES.—In the congested value district, static pressures with tank supply range from 120 to 159 pounds, and with reservoir supply, 236 to 328 pounds. The average pressure in the zone supplied by Jones Street tank is 130 pounds and in that served by Ashbury tank is 143 pounds. Indicating pressure gages are maintained at each tank. Recording gages on both zones are maintained at Pumping Station 2 and Fire Alarm headquarters; the Ashbury zone also has a recording gage at Engine 34 and the Jones zone gages at Engine 2 and Pumping Station 1. Any fluctuations in pressure are reported and promptly investigated.

DISTRIBUTION SYSTEM.—General.—The system was designed to furnish about any block near Third and Market Streets in the congested value district, 15,000 gallons a minute at a pressure of 229 pounds. Mains are connected at all intersections. The system is divided into two zones by gates normally closed. Supply to each zone is by gravity from a tank of fair capacity, with additional water available at high pressure from the reservoir. In order to permit more rapid control in the event of a break, eleven small areas at low elevation, where pipe is laid in infirm ground, are normally separated by closed valves from other parts of the system and supply is furnished through a single main. There are excellent arrangements for opening emergency connections, as well as coded signals over the fire

alarm system for opening valves from the reservoir to any zone or for starting the pumping stations.

Mains.—See accompanying map. Two 20-inch pipes extend about 2,200 feet northeasterly from Twin Peaks reservoir to Ashbury tank, where each, through five 8-inch valves normally closed, connects with an 18-inch header supplying three 18-inch arteries of the Ashbury zone. The first extends northerly 2.2 miles, the second 3.8 miles through the central portion of the zone to Jones Street tank, and the third 0.7 mile east to an emergency connection with an 18-inch Jones main. A 20-inch main from Pumping Station 2, extends southerly 1.1 miles, and there is a fire boat manifold connected to a 14-inch main ¼ mile west of the station. In the Ashbury zone, minor distributors are mostly 12- and 14-inch with a small amount of 10-inch, and in general form a gridiron well looped about areas of moderate extent. There is a loop of excessive size in the Park-Presidio district composed of 4¼ miles of 12-inch pipe, and a 12-inch dead end, 1¾ miles long, at the southwestern edge of the zone, supplies 28 hydrants.

Two 18-inch mains from Jones Street tank extend short distances east and south into the Jones zone; the first continues into the congested value district, which is also supplied by a 20-18-inch main 2½ miles long extending southerly and easterly from Pumping Station 2. Two 20-18-inch mains from Pumping Station 1 extend to Market Street by divergent routes and are cross-connected by an 18-inch which extends most of the length of that street. In the Jones zone, minor distributors are mostly 12- and 14-inch with small amounts of 10- and 16-inch, and form a generally close gridiron in congested districts. A 12-inch dead end, 2¼ miles long, through the industrial district south of Islais Creek, supplies 29 hydrants, but is provided with two fire boat manifolds for emergency use. There are three other manifolds connected to 14- or 16-inch pipes in the main portion of the zone.

PIPES.—For amount of each size in service, see Table 6. All pipes are tar coated cast-iron; 67 per cent were laid prior to 1913 and 29 per cent between 1934 and 1939; all have lead joints. Pipes are in sound condition, their carrying capacity has not been greatly reduced by tuberculation and no trouble has been reported from electrolysis. One fire flow test was made in the vicinity of 18th Avenue and Irving Street, on January 20, 1948. Adequate quantities for protection of the district are available from this long dead-ended 12-inch main when supplied by Twin Peaks reservoir. The test showed the excellent carrying capacity of the mains to this district. Pipes are installed with cover of 5 feet above the center line.

Pipe was purchased under special specifications which in general exceed ordinary requirements. Classes A to H were used, depending on pressures to which pipes might be subjected, and correspond closely by weights with those of the American Water Works Association. Lugs were required for tie-rods upon all pipes entering valves and specials, and upon hydrant connections. In filled-in areas double spigot pipes were installed with sleeves of cast steel.

GATE VALVES.—For number of each size in service, see Table 6. Gate valves are of special design with heavy cast-iron body, and bronze stems, parallel faces and seats; all open to the right. On 12-inch and larger mains, valves are 2 inches smaller in diameter; 16- and 18-inch valves have 3- and 4-inch by-passes; 12-inch and larger valves are geared and set in concrete vaults; 10-inch valves are operated through concrete cones or cast-iron valve boxes and 8-inch, through extension boxes. New valves 10 inches and larger in size are equipped with lubrication devices. Special valves have their function cast in the iron covers, and on valves normally closed, the covers are painted red on the under side; many valves have indicators and others are being so equipped.

Four valves, located on property lines, are provided at street intersections, so that in case of breakage or repair to the pipe system, only one side of a single block would have its supply shut off. Inspections are practically continuous, the entire system being covered about twice a year. The inspection of 20 line valves and 9 by-pass valves was observed by an engineer of the National Board of Fire Underwriters during the inspection; operation was by a mechanical closer or manually; valves, manholes and boxes were in good condition.

Table 6.—Pipes and Valves in High Pressure Distribution System, January 1, 1948*

Diameter, Inches	PIPE		Number of Gate Valves
	Length, Miles	Per Cent of Total	
10	13.00	12.52	840
12	45.65	43.96	327
14	18.25	17.57	97
16	7.23	6.96	230
18	15.27	14.70	45
20	4.46	4.29	....
Total....	103.86	100.00	1539

* Not including 5.79 miles of 8-inch pipe in hydrant connections and 1,353 8-inch gate valves.

HYDRANTS.—On April 29, 1948, 1,349 hydrants were in service. All are of post type, made locally, similar to the A. P. Smith design, and open to the left. Each has 8-inch gated connection to main, 10-inch barrel and three 3½-inch independently gated outlets, two of which are reduced to 3-inch. Where located in areaways beneath sidewalks, reinforced concrete vaults filled with sand, are provided. Hydrants are inspected about twice a year; necessary repairs are promptly made. Six hydrants were operated in the course of this survey; all were in good condition. Records of inspections and repairs are kept.

One hydrant is located at each street intersection where mains are installed, and intermediate hydrants, in long blocks; additional hydrants are installed in congested districts. There are 199 hydrants within and 68 adjacent to the congested value district; the average area served is 98,000 square feet. In other parts of the system the spacing is much wider, but in no case does the linear spacing exceed 900 feet. The use of hydrants is confined solely to the fire department for the extinguishment of fires.

CONCLUSIONS.—The high pressure system, the primary source of fire protection in the congested value and adjoining mercantile, industrial and closely built residential districts, permits the rapid concentration of powerful streams without the use of pumpers in the area served and is a protective feature of the greatest value. It is operated and maintained by competent and experienced officials.

The ability to supply the system from several widely separated and dependable sources gives it a high degree of reliability. The fresh water supply is sufficient and the salt water supply to pumping stations is inexhaustible. Unusual ability to resist earthquakes has been attained by careful selection of locations for reservoir, tanks, pumping stations and large pipe lines, and by substantial construction throughout. The fire boat manifolds constitute an additional source of supply and are of particular value to the single line in the southern part of the system.

The pressures usually maintained at hydrants are effective for use at ordinary fires; higher pressures can be obtained quickly. The distribution system in congested districts is well laid out and very strong. The partial segregation of pipe in infirm ground is a commendable precaution and with the means provided for opening additional gates if required, should not lead to trouble. Pipes are of sufficient weight and in sound condition; the greatest care was taken in their installation, particularly in filled ground. The reliability of the pipe system under adverse conditions is increased by the excellent valve spacing. Hydrants are of large size and good type and permit a concentration of fire streams. Both valves and hydrants are well maintained.

FIRE DEPARTMENT

ORGANIZATION.—General.—The fire department has been full paid since 1900; operation is on a 60-hour a week basis for firemen and 48-hour a week for marine crews. For fire-fighting purposes the city is divided into 3 divisions and 11 districts with an assistant chief in charge of each division and a battalion chief in charge of each district. Districts contain from 6 to 17 companies. Division 1 includes practically all of the congested value district.

The department is under the management of a board of fire commissioners, appointed by the mayor for 4-year terms. Present members are Max Sobel, president, Walter Leonetti and Robert H. Schaefer. They were appointed in January and April 1948, following the acceptance of resignations of two and the death of one of the previous members. The practice of appointing new fire commissioners is customary at each change of administration. The board has full control of the department and handles directly expenditures and appropriations, the enforcement of discipline, appointments, promotions and retirement of members, and numerous details usually handled more efficiently by chief officers.

Officers.—The chief is appointed by the board to serve during its pleasure. He is charged with the special duty of superintending the extinguishment of fires at which time he is permitted to exercise supreme command over the department members on duty. At other times he is the nominal executive head of the department with general direction of all members including the fire prevention bureau and high pressure system, subject to supervision of the board. Chief Edward P. Walsh was appointed in January 1948, after 26 years of service during which he advanced through the fire-fighting grades by successive promotions. A charter amendment, effective April 1, 1948, gives the chief power to appoint a deputy chief from the ranks of first or second assistant chiefs. At the time of this inspection all assistant chiefs were in turn given opportunity to act as deputy chief for a week at a time pending the appointment of deputy on July 1, 1948. The chief is on continuous duty; assistant chiefs are on platoon duty with regular response assignments.

Battalion chiefs are responsible for operation of their companies. As fire wardens they are assigned districts of the city in which they are required to enforce fire protective ordinances; these fire warden districts are not entirely the same areas in which they respond on first alarms. The board of chiefs, with the chief as chairman, has authority to investigate all matters pertaining to department efficiency and to make recommendations to the fire commissioners.

TABLE OF OFFICERS

Name	Age	Appt. to Present Position	Years in Service
Chief: Edward P. Walsh	52	1948	26
Deputy Chief: A. J. Galli	60	1948	35
1st Asst. Chiefs:			
M. J. Kearns	62	1937	38
Ed. D. O'Neill	58	1942	35
Acting, J. F. Kearney	65	1948	38
2nd Asst. Chiefs:			
P. A. McCormack	55	1946	29
C. F. Kruger	55	1947	27
T. J. Keohane	62	1945	36
James Fitzpatrick	64	1947	29
G. L. Trapp	61	1941	36
Fire Prevention and Investigation: F. P. Kelly	61	1937	38
Battalion Chiefs:			
Rudolph Schubert	71	1924	42
E. M. Coglan	50	1946	27
J. A. Cafferty	57	1947	27
R. C. Minkel	46	1945	19
Wm. H. Gilmore	39	1947	16
R. D. Anderson	40	1947	17
A. C. Derham	59	1941	33
D. J. Milani	46	1945	20
T. F. Webb, Jr.	51	1947	27
Wm. F. Murray	49	1945	27
J. J. Howard	56	1947	29
J. L. Pruyn	53	1947	25
F. P. Gibson	58	1945	34
J. J. Webb	50	1947	27
T. E. Kenney	62	1930	35
Lawrence Dillon	51	1945	24
F. A. Carew	63	1929	34
M. J. Flaherty	60	1930	38
B. H. Dever	58	1929	26
James Horan	52	1944	27
C. J. Conroy	63	1930	38
E. J. O'Meara	54	1947	29
V. E. Bertucci	56	1938	29
J. A. Smith	53	1946	29
Wm. J. Smith	61	1937	34
Edward O'Dowd	59	1939	29
Training:			
J. H. McLendon	49	1946	25
Mechanical Engineer:			
R. D. Keeley	41	1946	2

Expenses.—Expenses of the fire department during the past five years, including the high pressure system but omitting fire alarm costs, have averaged $4,197,515; for 1946-47 they amounted to $5,189,492 which is an average per capita expense for maintenance of $6.70 based on an estimated population of 775,000. The State pays half of the expense of maintenance of the two fire boats. A total of $355,338 has been expended in the last 3 years for new apparatus and stations.

Membership.—See Table. Total membership in April, 1948, was 1,632 with a fire force of 1,510. Authorized membership was 1,638.

FIRE DEPARTMENT MEMBERSHIP

Chief Officers	36
Captains	75
Lieutenants	138
Chiefs' Operators	38
Marine Crews	30
Engineers	3
Firemen	1190
Fire Force	1510
Staff	17
Fire Prevention and Investigation	40
High Pressure System	38
Training	7
Mechanics	7
Assignment Office	6
Harbor	3
Employees	4
Total	1632

Appointment and Promotion.—Except for the chief, secretary and physician, who serve at the pleasure of the board, and the deputy chief who is to be appointed by the chief, all original appointments and promotions are made by the board under civil service regulations. Applicants for original appointment must pass medical, athletic and written examinations. Age limits are 21 to 35; minimum height and weight limits are 5 feet 7 inches and 140 pounds; probationary period, six months. Final appointment is subject to favorable reports of company officers and the drill master, and on results of a second medical examination. Promotions are based mainly on written examinations with considerable credit for seniority. Chiefs' operators, pumper operators and drivers are appointed by the chief.

Retirement and Pension.—The pension fund is supported by contributions from the city, and from members in amounts determined by an actuary. Half-salary pensions are paid members who entered the service before 1932, on retirement after 20 years' service at the age of 55, and after 25 years' continuous service. Pensions, in amounts determined by an actuary, are given after 30 years' service to members who entered the service since that date; retirement in each case is optional. Provision is made for dependents. Compensation is provided during disability, and benefits paid dependents of members killed in line of duty. Members over 60 years of age may be forced to retire for the good of the service by unanimous vote of the board. Retirement is compulsory at age 70. The department records show that 126 members are over 55 years of age, 50 are over 60 years and 14 are 65 years or older.

Companies.—Forty-seven pumper, 17 ladder, 14 booster tank, 2 fire boat, 2 fire boat tender, 4 salvage, 4 water tower, 2 rescue, an air compressor, a fuel supply and 2 searchlight companies are in service in 56 stations. A captain or lieutenant is on duty at most times in each pumper, ladder, fire boat, salvage and rescue company. Regular and relief drivers, pumper operators and tillermen are provided and other members are trained as substitutes. Each chief officer on fire duty has a driver who acts as an aide.

Excepting marine crews, members of the fire force work 15-day tours of duty, each tour consisting of 6 or 4 day shifts followed by 72 hours off duty and 5 or 6 night shifts followed by 48 or 72 hours off duty. Shifts change at 8 A.M. and 6 P.M.; tours alternate semi-annually. Marine crews work 24-hour shifts and a 48-hour week. Annual vacations are for 14 days; vacations are distributed throughout most of the year. The average number sick or disabled is 35. Relief company officers are provided; battalion chiefs are relieved by senior captains and assistant chiefs by battalion chiefs. Continuous watch is maintained in all stations.

By charter provision, members may be kept on duty not more than 14 consecutive hours, except when changing tours or for a conflagration requiring the service of more than half of the force. Telephone numbers of all members are on file at fire stations and at the assignment office.

Within or near boundaries of the congested value district are 6 pumper, a booster tank, 2 rescue squad, 2 water tower, an air compressor, a floodlight and 3 ladder companies; no building is more distant than ¾-mile from 3 or more pumper companies or one mile from 2 ladder trucks. Within 1½ miles of Third and Market Streets are in addition, 7 pumper, 2 ladder, 2 booster tank, 2 salvage, a floodlight and 2 water tower companies. Manufacturing, mercantile, and high value apartment house districts have pumper protection within ¾-mile and, with few exceptions, ladder protection within one mile. The two fire boats are available along the waterfront for large water lines and as an emergency source of supply for the high pressure system.

Small stream service from booster tank companies is good except in the Sunset district and the western part of the Richmond district. Small stream service from 1½-inch hose is good in all parts of the city. Most buildings six stories or over in height are within 1½ miles of the taller water towers, and all of the district bounded by Van Ness Avenue, 11th and Division Streets and the waterfront has water tower protection and searchlight service within 1½ miles.

EQUIPMENT.—General.—Thirteen pumpers, 4 tractors and the two fire boat tenders have been in service over 20 years, including 3 pumpers and a tractor with more than 25 years of service. The fire boats have had 39 years of service.

Pumpers. — In service are 20 American-LaFrance, 15 Seagrave, 12 Mack, an Ahrens-Fox and a Stutz pumpers; in reserve are 5 American-LaFrance and 7 Seagrave pumpers. With the exception of one of 1,000 gallons capacity all reserve pumpers are of 750 gallons capacity. All have divided hose bodies. Each carries two 12-foot lengths of 5-inch drafting suction and one 12- and one 6-foot lengths of 3-inch flexible suction hose. One has a piston pump, 8 have rotary pumps and others are of centrifugal type.

Fire Boats.—Fire boats Dennis T. Sullivan and David Scannell are in service at the foot of Harrison Street and at the foot of Bay Street, respectively. In addition to the marine crew, an officer and six hosemen are on duty on each. They are twin ships with steel hulls and twin screws, built in 1909. Length, beam and draft are respectively 120, 26 and 11 feet. Gross tonnage is 240; net tonnage, 140. Speed is 12 miles an hour. Power equipment includes: Two Babcock & Wilcox oil burning boilers; two vertical compound condensing propelling engines, and two turbines each driving a 2-stage Byron-Jackson centrifugal pump of 4,500 gallons capacity at 150 pounds pressure; pumps are cross connected for operation in series or parallel.

Fire fighting equipment includes monitors over the pilot house and deck house, a telescopic tower elevating to 54 feet above water, and two portable monitors which may be mounted at either side of the deck or over the aft deck house. Nozzle tips range from 2 to 2¾ inches in diameter. Two manifolds, each with ten 3½-inch outlets reduced to 3-inch, are mounted, without cross connection, at each side above the deck house. Each boat carries 800 feet of 1½-inch and 4,000 or 5,000 feet of 3½-inch hose, is equipped with radio receiver, steam winches, steam steering gear, 10-kw. generator, searchlight, portable flood lights and has a perforated pipe water curtain extending around the deck house. Hose tenders are located at Station 19 and at the foot of Bay Street. From 3- to 4-mile runs are necessary for the nearest fire boat to reach the more distant parts of the southern waterfront.

Pumper Tests.—Fifteen representative pumpers were tested at draft during this survey to determine their condition and the proficiency of their operators. All but Pumpers 12, 37 and a reserve pumper were able to deliver their rated capacities. Pumper 12 failed, due to lubrication trouble and had to be towed to the shop. On first test, the motor of Pumper 37 overheated, due to an obstruction in the cooling system. On a subsequent test Pumper 37 was able to deliver its rated capacity only when the foot throttle was fully depressed. A reserve pumper of 1916 model

was able to pump 90 per cent of capacity for 10 minutes, after which the test was discontinued because of unsteady and irregular running. Throttles of 4 pumpers had excessive play in their linkages or were not rigid, 3 pressure governors were in poor condition, a fuel gage and a temperature indicator were inoperative, a muffler was broken and a tachometer was 13 per cent out of adjustment. With few exceptions the proficiency of operators was only fair; two were poor. Operating deficiencies included improper use of pump stages, cold motor operation and failure to set clutch locks.

Ladder Trucks. — Two Seagrave and two Ahrens-Fox 85-foot aerial trucks purchased between 1939 and 1946 and 13 old service ladder trucks either built or altered in the municipal shop to conform to the city design, are in service, and one aerial and 3 service ladder trucks are in reserve. With few exceptions all carry 65- and 50-foot extensions, 35- and 32-foot straight ladders and 8 to 13 other ladders including 4 pompiers and two with roof hooks. All have 4-wheel tractors which are interchangeable with those used on the smaller water towers and all have tillers. Nine tractors are in reserve. The top-heavy construction of service ladder trucks has caused accidents when turning too quickly.

Hose Wagons.—In addition to the pumpers carrying hose, eight hose wagons are in service, six with pumper companies and two as fire boat tenders. Each of the hose wagons in pumper companies carries 2,000 feet of 3-inch hose in a divided body; each fire boat tender carries 4,000 feet of 3½-inch hose in a 4-compartment body. All are equipped with turret pipes. Five reserve hose wagons are provided.

Small Stream Service.—Twelve booster tank wagons, each with 400- to 500-gallon water tanks and 600 feet of 1-inch hose, a 500-gallon pumper with 350-gallon water tank and 200 feet of 1½-inch hose in addition to the 1-inch, and a 600-gallon pumper with 350-gallon water tank and 700 feet of 2¾-inch hose in addition to smaller hose, furnish most of the small stream service. The booster tank wagons and small pumpers are of 4 different makes. Other pumpers carry 200 feet of 1½-inch hose with ⅜- and ¾-inch tips and combination spray and straight stream nozzles. About one-third of the portable extinguishers are of forestry and others are of soda and acid type; lacking are foam and carbon-dioxide types. Each booster tank wagon and each pumper carries a combined spray and straight stream nozzle for use on 1- or 1½-inch hose; applicators are carried by a few ladder trucks.

Salvage Equipment. — Four salvage wagons, built on International and Reo chassis of 1930 and 1939 models, are in service and one is in reserve. Each wagon carries 75 stock and 4 roof covers, squeegees, sprinkler heads, sprinkler shutoffs, brooms, buckets, shovels and two gas masks. A Chrysler 500-gallon trailer pump is used for dewatering flooded areas. No salvage equipment is carried by pumper or ladder companies.

Powerful and Special Stream Appliances.—The 75-foot and 60-foot Gorter water towers were built in 1902 and 1898, respectively. Each has an independent deck pipe with interchangeable 1½- to 2½-inch tips. The 31-foot water towers were built in 1927. Each has an independent deck pipe with 1¾- to 2¼-inch tips. All of the water towers are raised by hydraulic motors which are slow in operation and require connection to a pumper or high pressure hydrant before raising. Eight 3-inch inlets are provided on each.

Aerial ladder trucks Nos. 3 and 6 carry a ladder pipe having 1¼- to 1¾-inch tips and 100 feet of 2½-inch hose. Each ladder truck has a balcony pipe with 1½-inch nozzle tip. Each pumper carries one or two reducing valves designed for supplying two lines, open nozzles with 1½- and 2-inch tips with Siamese connection and nozzle holder and two distributing nozzles. Seven booster tank wagons carry foam generators with 4 to 6 cans of powder. A Ford truck stationed with Pumper 29 carries 2 foam generators and 36 cans of powder.

Emergency Equipment.—The rescue wagon in service with Ladder 1, built in the municipal shops on a 1930 Mack chassis, carries complete first-aid equipment, 8 oxygen and 4 gas masks, fresh air breathing equipment, oxy-acetylene cutting set and a loud speaker. The utility wagon in service with Pumper 4 is built on a 1942 Dodge chassis and carries much of the same equipment as does the rescue wagon, with the addition of a 1,250-watt lighting generator and flood lights.

Both searchlight wagons were assembled at the municipal shops, using Kleiber 2-ton truck chassis of 1929 model upon which are mounted 10-kw. Kohler generators. Each wagon has five 1,000-watt flood lamps, mounted on an elevated platform, and eight 400-watt portable focusing lamps, each equipped with stand and 500 feet of cable. Six ladder trucks each carry a portable 1,250- or 1,500-watt lighting generator with 500- and 250-watt flood lights.

Assembled in the municipal shops in 1930 on a 1926 White chassis, the air compressor carries a 160-cubic foot compressor unit, 5 air guns, smoke extractor and various tools for breaking concrete or cutting wood.

A 4-wheel drive Kenworth towing tractor of 1940 model, stationed with Pumper 29, is equipped with capstan, hoist and 15-ton dolly.

A coffee wagon, stationed with Pumper 25, carries coffee urns and a supply of coffee, milk and sugar and is used in case of extra alarm fires.

TABLE 7.—FIRE COMPANIES—LOCATION AND EQUIPMENT.

Pumper Companies

Company	Location	Members on Duty	Apparatus Type
Pump. 1*hv*	Pacific Ave., nr. Montgomery St.	7	1000-gal. Pump. Hose Wagon *
" 2*hv*	Bush St., near Grant Ave.	6	1000-gal. Pump.
" 3*hv*	Post St., nr. Polk St.	6	1000-gal. Pump.
" 4*hv*	Howard St., near 3rd St.	6	1000-gal. Pump.
" 6*hv*	Seventh St., near Harrison St.	6	1000-gal. Pump.
" 7*hv*	Sixteenth and Albion Sts.	6	1000-gal. Pump.
" 8*hv*	Pacific Ave., nr. Polk St.	7	1000-gal. Pump. Hose Wagon *
" 9*hv*	Embarcadero, ft. of Harrison St.	6	1000-gal. Pump.
" 10*hv*	Seventeenth St., nr. Folsom St.	7	1000-gal. Pump. Hose Wagon *
" 11	Oakdale Ave., nr. 3rd St.	5	1000-gal. Pump.
" 12*hv*	Drumm & Commercial Sts.	7	1000-gal. Pump. Hose Wagon *
" 13	Valencia St., nr. 26th St.	6	1000-gal. Pump.
" 14	McAllister St., nr. Webster St.	6	1000-gal. Pump.
" 15	California St., nr. Laguna St.	6	1000-gal. Pump.
" 16*hv*	Tennessee St., nr. 20th St.	6	1000-gal. Pump.
" 17*hv*	Jessie St., nr. 5th St.	7	1000-gal. Pump. Hose Wagon *
" 18	Girard St. and Wilde Ave.	5	1000-gal. Pump.
" 19	Third & Fourth Sts.	6	1000-gal. Pump.
" 20	Greenwich St., nr. Steiner St.	6	1000-gal. Pump.
" 21	Oak Street, near Broderick St.	6	1000-gal. Pump.
" 22	Tenth Ave., near Irving St.	5	1000-gal. Pump.
" 23	Washington St., nr. Broderick St.	5	1000-gal. Pump.
" 24	Hoffman Ave. & Alvarado St.	5	750-gal. Pump.
" 25	Third St., near Arthur Ave.	6	1000-gal. Pump.
" 26	Sacramento St., nr. Maple St.	5	1000-gal. Pump.
" 27	Waller St., near Laguna St.	6	1000-gal. Pump.
" 28*hv*	Stockton St., nr. Greenwich St.	5	1000-gal. Pump.
" 29*hv*	Division St., nr. Tenth St.	6	1000-gal. Pump.
" 31	Green St., near Leavenworth St.	6	1000-gal. Pump.
" 32	Park St. & Holly Park Circle W.	5	1000-gal. Pump.

TABLE 7.—FIRE COMPANIES—LOCATION AND EQUIPMENT.—Continued

Pumper Companies

Company	Location	Members on Duty	Apparatus Type
Pump. 33	Broad St., near Plymouth Ave.	5	1000-gal. Pump.
" 34*hv*	Ellis Street, near Gough St.	7	1000-gal. Pump. Hose Wagon *
" 35*hv*	Bluxome St., bet. 4th & 5th Sts.	6	1000-gal. Pump.
" 36	26th Ave., near Geary Blvd.	5	1000-gal. Pump.
" 37	Twenty-fifth and Vermont Sts.	5	1000-gal. Pump.
" 38	San Jose and Ocean Aves.	5	1000-gal. Pump.
" 39	Portola Dr., opp. Kensington Way.	5	1000-gal. Pump.
" 40	Clayton & Carmel Sts.	5	750-gal. Pump.
" 41	Leavenworth St., nr. Clay St.	6	1000-gal. Pump.
" 42	San Bruno Ave., nr. Silver Ave.	5	1000-gal. Pump.
" 43	Brazil Ave., near Athens St.	5	750-gal. Pump.
" 44	22nd St., nr. Noe St.	5	750-gal. Pump.
" 45	Forty-fifth Ave., nr. Irving St.	5	750-gal. Pump.
" 46*hv*	Twelfth Ave., nr. Geary Blvd.	5	1000-gal. Pump.
" 47	Forty-first Ave. & Geary Blvd.	5	1000-gal. Pump.
" 48	Wisconsin & 22nd Sts.	5	750-gal. Pump.
" 49	Eighteenth Ave., nr. Rivera St.	5	1000-gal. Pump.

Fuel Truck.—A 1923 tank truck, in service with Pumper 4, carries one 100-gallon lubricating oil and two 250-gallon gasoline tanks; it is kept loaded and is called for as required. Tank outlets are equipped with fusible shut-off links. The driver is detailed from one of the companies. Gasoline supplies are provided in underground tanks or portable buggies at all fire stations.

Chiefs' and Other Automobiles and Trucks.—Sedans are provided for the fire commissioners, chief and assistant chief officers and coupes for battalion chiefs, members of the fire prevention bureau, mechanics, instructors and the salvage captain. Various trucks and automobiles are used in high pressure system maintenance, delivery of supplies and in repair service.

Hose.—All 1½-inch and larger hose is double-jacketed cotton, rubber-lined, of good grade, purchased under the department's own specifications,

TABLE 7.—FIRE COMPANIES—LOCATION AND EQUIPMENT.—Continued

LADDER COMPANIES

Company	Location	Members on Duty	Apparatus Type
Lad. 1*hv*	Jessie St., nr. 5th St.	7	65-ft. Service
" 2*hv*	Powell St., near Pacific Ave.	7	65-ft. Service
" 3*hv*	With Pumper 3	7	85-ft. Aerial
" 4*hv*	With Pumper 8	7	65-ft. Service
" 5	Geary St., nr. Scott St.	6	65-ft. Service
" 6	Hermann St., nr. Fillmore St.	7	85-ft. Aerial
" 7*hv*	With Pumper 10	7	65-ft. Service
" 8*hv*	With Pumper 35	7	85-ft. Aerial
" 9	With Pumper 37	7	65-ft. Service
" 10	With Pumper 26	7	65-ft. Service
" 11	Duncan St., near Church St.	7	65-ft. Service
" 12	Waller St., near Stanyan St.	6	65-ft. Service
" 13*hv*	With Pumper 12	7	85-ft. Aerial
" 14	With Pumper 36	7	65-ft. Service
" 15	With Pumper 39	6	65-ft. Service
" 16	With Pumper 20	7	65-ft. Service
" 17	With Pumper 11	7	65-ft. Service

BOOSTER TANK COMPANIES

Company	Location	Members on Duty	Apparatus Type
1	With Pumper 28	2	Booster Tank
2	With Ladder 5	2	Booster Tank
3	With Pumper 2	2	Booster Tank
4	With Pumper 14	2	Booster Tank
5	With Ladder 12	2	Booster Tank
6	With Pumper 20	2	Booster Tank *
7	With Ladder 11	2	Booster Tank
8	With Pumper 6	2	Booster Tank
9	With Ladder 6	2	Booster Tank
10	With Pumper 38	2	Booster Tank
11	With Pumper 10	2	Booster Tank
12	With Pumper 39	2	Booster Tank
13	With Pumper 46	2	Booster Tank *
14	With Pumper 11	2	Booster Tank *

MISCELLANEOUS COMPANIES

Company	Location	Members on Duty	Apparatus Type
Fire Boat 1	Ft. of Harrison St.	12	Fire Boat
Tender 3	With Pumper 19	1	Hose Wagon *
Fire Boat 2	Ft. of Bay St.	12	Fire Boat
Tender 2	Ft. of Bay St.	1	Hose Wagon *
Rescue 1	With Ladder 1	6	Rescue
Rescue 2	With Pumper 4	6	Rescue
Salvage 1	Natoma St., near	5	Salvage Wagon
	New Montgomery St.	5	Salvage Wagon
Salvage 2	Octavia St., near	4	Salvage Wagon
	McAllister St.	4	Salvage Wagon
Water Tower			
1	With Pumper 4	2	75′ Water Tower
2	With Pumper 4	1	60′ Water Tower
3	With Pumper 19	1	31′ Water Tower
4	With Ladder 2	1	31′ Water Tower
Searchlight			
1	With Pumper 4	1	Flood Light
2	With Ladder 2	1	Flood Light
Air Comp.	With Pumper 12	1	Air Compressor

hv Company located in or near High Value District.
* Equipped with Turret Pipe.

with a 3-year guarantee. New hose is given complete tests including pressure tests at 400 pounds on each length and tests for chemical composition, friction, elasticity and tensile strength on every tenth section. After one year of service hose is tested at 300 pounds. The 2¾-inch size with 3-inch couplings is used instead of 2½-inch hose. Quarterly service tests are made in stations at 200 pounds pump pressure. Defective lengths are repaired, classed as second grade or condemned. Before 5 years of service, hose is again tested at 400 pounds and redistributed among outlying companies. Towers or drying racks are provided at all fire stations.

The 2¾- and 3½-inch hose couplings have National Standard 3- and 3½-inch threads. Each high pressure hydrant has three 3½-inch outlets, two of which are reduced to 3-inch. Excepting about 100 low pressure hydrants with 2½-inch outlets, all have 3-inch outlets of National Standard dimensions. Shut-off valves, distributing nozzles and 2½-inch hydrant outlets have 2½-inch threads of approximate National Standard dimensions. Pumper companies carry full sets of increasers and reducers which permit interconnection of various sizes of hose.

Minor Equipment.—Minor equipment on pumpers and ladder trucks is distributed uniformly and

is mainly complete. Appliances needed are listed under Recommendations. Radio receivers tuned to the police department transmitter are on the fire boats and in automobiles of chief officers.

Repairs.—Minor repairs are made at fire stations by six detailed firemen of the automobile school under supervision of Geo. F. Van Oorschot, Inspector. One of the mechanics is on call at all times. During 1946-47 there were 54 cases of mechanical failure of apparatus to respond to alarms; during 1937-38 there were only 25 such cases. Major repairs are made at the municipal shops under supervision of the purchasing department and the capable direction of General Superintendent Harold Jones, who has had extensive experience in fire department repair work. The shop force consists of 40 men. The shops are well equipped to make all fire department repairs, including painting, manufacture of ladders, nozzles and fittings, and tests of pumpers and hose. A fair supply of apparatus parts is kept in stock. Acting Superintendent of Equipment R. D. Keeley has supervision over the high pressure system, its reservoirs, pumping stations, domestic system hydrants and the fire boats.

Fire Stations.—Excepting two of fireproof and two of steel frame construction, stations are about equally of wood frame and ordinary construction, the latter type offering little resistance to earthquake stresses. Many of the wood frame stations are in only fair condition. Stations 10, 11, 14, and that of Ladder Company 6 of frame construction and Station 27, of ordinary construction, are in poor condition. In the event of a serious earthquake severe damage or even collapse of some of the ordinary masonry type stations may be expected with resulting disablement of apparatus and demoralization of personnel.

OPERATION.—Discipline.—The department is governed by rules and regulations of 1928 to which a few amendments have been added, and by general orders, issued on occasion. Written charges, preferred by company officers, are forwarded through channels to the chief, who may suspend a member pending trial. All chief officers have the power to suspend members summarily. The board of fire commissioners serves as the trial board. Hearings are public; defendants may be represented by counsel and witnesses examined under oath. The board may reprimand, suspend, fine or dismiss, and its action unless appealed to the courts is final. Penalties for infractions of rules almost invariably consist of short suspensions. The administration of discipline by past boards of fire commissioners has not always been free from outside influences. Records of discipline kept by the secretary of the board are referred to by the civil service board when making promotions.

Drills and Training.—Battalion Chief J. H. McLendon is in charge of training. He is assisted by two lieutenants who have had experience as military instructors. The fire college was inaugurated in October, 1947, as a part of the San Francisco City College. During this survey company officers were trained as teachers by Thomas S. Ward, Instructor of State Vocational Training.

Firemen, detailed from companies in classes of 25, attend morning lectures for one week, witness demonstrations of devices and equipment and conclude the lecture course with a written examination. The same class with the addition of 15 other detailed members participate in afternoon drills with ladders, hose and equipment at the department drill tower.

Captain W. E. Gallatin has been in charge of tower drills since 1932. He is assisted by company officers detailed as needed. A well equipped 7-story steel frame and brick drill tower, located near Station 29, has facilities for pompier drills, fire escape and standpipe practice, use of gas masks and study of ventilation. Morning and afternoon sessions are held at the drill tower usually 5 days a week.

Combined drills, simulating fire conditions with two pumper companies operating as units in charge of the instructor, are held on four mornings of each week and two pumper companies in combination with a ladder company drill together on one morning of each week. Ladders and ropes are tested at 2-year intervals.

Company drills are held weekly at fire stations, sometimes under supervision of district chiefs. Pumpers are operated monthly at dock, cistern, reservoir or hydrant. Driving and pumping instruction is given and annual condition tests are conducted by members of the automobile school.

Response to Alarms.—The usual response to box alarms is in the table, the amount of apparatus for second and subsequent alarms, including previous response.

In addition, first alarms include the response of an assistant and a battalion chief, a booster tank company except in the more distant parts of the Sunset district, a salvage company in the northeastern part of the city bounded approximately by Divisadero and 16th Streets, a rescue squad in the congested value and main industrial districts and a fire boat along the waterfront. Fire boat tenders respond on third or greater alarms. The chief attends all second and some first alarms. Water towers, searchlight wagons, the air compressor and fuel wagon respond only on special calls; provision is made for special response of any company. Response to telephone alarms for building fires is the same as to box alarms. To still alarms the nearest booster tank or pumper company and a battalion chief are dispatched.

The running card provides for response to five alarms and moving of companies on second and subsequent alarms to protect uncovered districts. All companies are listed on all cards. Vicinity boxes, to which only one pumper company responds, are designated.

The officers on duty at the assignment office direct distribution of companies under abnormal conditions or for extended first alarm fires. Apparatus is sent out of the city infrequently to aid neighboring cities. One of the fire boats is available for waterfront fires in any part of the bay.

One or more automobile mechanics respond to second alarms if on duty. On third alarms the drill and fire college classes, if in session, gatemen of the high pressure system and an offshift crew of each high pressure pumping station, attend.

RESPONSE TO ALARMS

District	Alarms	Pumpers	Hose Wagons	Ladder Trucks	Chief Officers
Congested Value, Apartments, Docks and Important Manufacturing	1	3	1	2	2
	2	7	2	3	4
	3	12	3 or 4	5	5
	4	17	5	6	6
	5	22	6	7	7
Western, Mission and Important Mercantile	1	3	0 or 1	1 or 2	2
	2	7	1 or 2	2 or 3	4
	3	12	2 or 3	4 or 5	5
	4	17	4 or 5	5 or 6	6
	5	22	5 or 6	6 or 7	7
Richmond, Sunset and Outlying	1	2 or 3	0	1	1
	2	6 or 7	0	2	3
	3	10 to 12	1	4	4
	4	15 to 17	2	5	5
	5	20 to 22	3	6	6

When a humidity of less than 30 per cent is accompanied by a wind velocity greater than 20 miles per hour and 10 or more companies are not available for response to alarms an emergency warning signal is transmitted. A modified assignment signal, transmitted when many companies are not available for response, limits first alarm assignments to 2 pumper, a ladder and booster tank companies and subsequent alarms to a ladder and 3 pumper companies. An emergency duty signal is given when, in the opinion of the chief or acting chief, all offshift members are required; they are then called by company officers who are in stations or by the assignment office when stations are vacant. A fourth emergency signal further limits first alarm assignments to a pumper and a booster tank companies. A total of 673 offshift members worked at a daytime fire on April 10, 1947.

The congested value, manufacturing, Mission, Richmond, and Sunset districts are fairly level, but steep grades are encountered in other parts of the city. Passenger trains at grade crossings occasionally delay fire apparatus south of the congested value district. Traffic warning gongs, operated from the fire alarm office, aid response along Market Street and over draw-bridges along the channel. The crossing of Market Street by apparatus is avoided when possible and special orders are issued to this end at the times when long parades are passing. All alarms, special calls and signals indicating chiefs and fire boats in or out of service are broadcast by radio.

Fire Methods.—Pumper companies usually lay hose from fire to hydrant and connect pumpers to domestic system hydrants using the shorter 3-inch flexible suctions; second pumpers are occasionally connected to hydrants using 12-foot suction. A pumping pressure of 120 pounds is required unless otherwise ordered. Hose is laid differently in the two compartments of hose bodies to facilitate laying in either direction, and double connections are carried for use when two lines are laid at once.

The high pressure system is used regularly in preference to the domestic supply, supplying lines through pressure regulators, attended by a pumper operator at each hydrant. For serious fires, pressure is increased by turning in Ashbury Heights tank or Twin Peaks reservoir.

Little hesitancy is shown in the use of powerful streams from turret pipes, ladder pipes and water towers. Having no cellar pipes, it is necessary to use distributing nozzles on basement fires which cannot be attacked directly by streams from hand lines. General use is made of balcony pipes connected to standpipes with which most of the buildings 4 stories and higher are equipped. The second pumper company is required to connect its first line to the automatic sprinkler siamese of a building so protected.

During 1946-47, the salvage companies answered 3,560 alarms and placed 4,708 stock and 838 roof covers.

Building Inspections.—No building inspections are made by company members. Battalion chiefs are required to make five building inspection reports monthly, including diagrams of main floors. These reports are filed without being used in conferences to familiarize the fire fighting force with important buildings, plants and available private fire protection facilities. Stations are visited frequently by battalion chiefs and are given a general inspection semi-annually by assistant chiefs. For inspections made by the division of fire prevention and investigation see Fire Prevention, page 41.

Records and Reports.—Journal, property and supply books are kept by company officers and

record is made of hose tests; monthly reports of company operations, supplies used, mileage, etc., are submitted to battalion chiefs for approval and transmitted to division chiefs. The assignment office keeps records of details, vacations and personnel, and makes daily membership reports to headquarters. Records of apparatus, repairs and supplies are kept at the automobile school. Fairly complete fire reports are made out by battalion chiefs. The chief makes recommendations to the fire commission annually in connection with the budget and at other times as occasion demands.

Summary of Apparatus

	In Service	In Reserve
Pumpers:		
1000-gallon	41	1
750-gallon	6	16
600-gallon	0	1
500-gallon	0	1
Hose Wagons:		
Plain	6	5
Fire Boat Tenders	2	0
Booster Tank Wagons	14	0
Ladder Trucks:		
Aerial	4	1
Service	13	3
Fire Boats	2	0
Rescue Wagons	2	0
Salvage Wagons	4	1
Light Wagons	2	0
Water Towers	4	0
Chiefs' Automobiles	34	17
Fuel Wagon	1	0
Trucks	23	0
Hose, 1½-inch	34,900′	7,100′
Hose, 2¾-inch	120,800′	19,200′
Hose, 3-inch	31,000′	6,150′
Hose, 3½-inch	25,900′	3,500′
Hose, 1-inch for Boosters	11,450′	600′
Ladders, Total Length	8,311′	379′
Ladders, Short, on Hose Wagons, Etc.	146	16
Portable Extinguishers	150	0
Chemical Tanks	0	8
Water Tanks	14	1
Gas Masks	178	0
Oxygen Masks	8	0
Fresh Air Masks	2	0
Salvage Covers	1110	0
Mounted Turrets	11	5
Deluge Sets	48	6
Ladder Pipes	2	0
Distributing Nozzles	80	6
Foam Generators	9	0
Portable Light Generators	7	0

IMPROVEMENTS.—Since the 1939 National Board of Fire Underwriters report the position of Deputy Chief was created, the third division was established, 4 additional assistant chiefs, 4 additional battalion chiefs and 372 additional members were added to the fire force. A. J. Galli was appointed deputy chief on July 1, 1948. Seven chemical companies were equipped with modern booster tank apparatus and an additional booster tank company and rescue squad were installed. Eleven pumpers, 4 aerial and 2 service ladder trucks, and two tractors were purchased, use of spray nozzles and 3-inch hose was inaugurated, two fire stations were built in partial replacement of many in poor condition, the salvage companies were incorporated in the fire department and a drill school was established.

Installation of a modern radio communication system to include fire stations as well as mobile units on the fire department's own channel is under way. Construction of a fire station on Sanchez Street near Market Street to house Pumper Company 27, Ladder Company 6, Booster Tank Company 9 and Salvage Companies 2 and 2a, and one on 32nd Avenue near Pacheco Street in the Sunset district to house new pumper and ladder companies are contemplated. It is expected that operation on the 56-hour a week basis with addition of 69 members to the fire force will start on July 1, 1948. Since this inspection was made five new 1,000-gallon pumpers have been put in service, replacing 750-gallon pumpers, two new booster wagons have replaced the booster wagons with 500- and 600-gallon pumps, and two new tractors have been provided for ladder trucks. Three more 1,000-gallon pumpers are on order.

CONCLUSIONS.—The fire department is a well organized and generally efficient force with mainly sufficient and well manned companies, though part are not equipped with the proper type of apparatus.

Administration of the department by former commissioners who have not made full use of the chief's experience and have delegated little or no authority to him has had a bad effect upon discipline, which has been intensified by their lenient handling of delinquencies and failure to require the retirement of numerous company members who are too old for active fire duty. Department rules and regulations are out of date and should be completely revised and brought into agreement with changes in organization and operation during the past 20 years.

Recent improvements in training, including drilling of companies as units and instruction of classes at the fire college, are in line with best modern practice, but a specially constructed building in which members can practice extinguishing various types of fires is needed.

Distribution of companies with respect to valuable and hazardous districts permits rapid concentrations of men and apparatus for serious fires, and companies are sufficient in number to handle simultaneous fires; however, an additional pumper

company and a ladder company are needed in the southwestern part of the city. Many of the pumpers are old and most of the ladder companies have service trucks instead of aerials.

Hose supply is adequate and well cared for, and a good supply of large hose is carried on fire boat tenders to provide an independent supply for several blocks inland from the waterfront.

The established custom of former chiefs who considered it their duty to take personal charge of operations at every multiple alarm fire has resulted in preventing assistant chiefs from gaining experience in command, except during the absence of the chief or on those infrequent occasions when simultaneous multiple alarm fires occur.

The lack of building inspections by company members is a handicap to them in case of fire because of unfamiliarity with building construction and contents.

FIRE ALARM SYSTEM

ORGANIZATION.—The fire alarm system is operated and maintained by the department of electricity. Gordon C. Osborne, formerly superintendent of plant, has been chief of the department since February 7, 1948. D. O. Townsend is acting superintendent of plant. Other activities of the department include manufacture of fire alarm boxes and apparatus, repair and maintenance of street traffic signals, maintenance of police signaling systems, repair and maintenance of parking meters and inspection of electrical wiring and appliances. The operating force is composed of 8 telegraph and 4 telephone operators under V. W. Clark, chief operator. The maintenance force consists of a foreman, 13 linemen, 3 electricians, 2 cable splicers, 4 radio technicians, a painter and 5 laborers. The shop force consists of a foreman, 4 instrument makers and 2 machinists.

HEADQUARTERS.—The central office is in a one-story and basement building of fireproof construction, erected in 1915 at Turk and Octavia Streets in Jefferson Square, a public park. The building is unexposed, windows have wired glass in metal sash and doors are labelled, of self-closing type. Heating is by gas-fired steam boiler.

EQUIPMENT. — Apparatus at Headquarters. —Apparatus is of manual type and local manufacture or assembly consisting of a cable terminal in the basement lacking protection facilities, and operating boards, central desk, power and lighting circuit control boards and telephone board on the first floor. Operating boards are arranged in a semi-circle with control desk at the center in a large and well lighted room which also contains the fire department assignment office, street traffic control equipment and the police radio transmitter.

Each box circuit has a milliammeter, pilot light, illuminated box list, power transferring and ground testing switches, rheostat, sounder, silencing switch and, in each side of the circuit, a signal key and relay. On a shelf in front of each panel are one or two inking registers. During receipt of an alarm, visible indications are given at the box circuit panel by the illuminated box list, pilot light and milliammeter, audible indication by a sounder and signal is recorded by one pen of a register.

Each alarm circuit has a milliammeter, illuminated station list, power transferring switches, ground testing switch, rheostat, supervising relay and register relay. Weak supervisory current, supplied by dynamotors, is interrupted by operation of multiple contact relays and 240-volt direct current thrown directly on the lines for sending out signals. During transmission of alarms all sounders are silenced and a pilot lamp is lighted at the telephone board. Outgoing signals are recorded by a 2-pen register at the central desk.

Hospital facilities are provided for 6 alarm and 5 box circuits. A special hospital panel provides more sensitive voltmeter tests for all circuits.

Apparatus is incomplete, lacking mechanical transmitters, time stamps, low current supervision, facilities to telephone over box circuits, and sufficient hospital circuit facilities for box circuits. The State harbor auxiliary fire alarm system connects to pilot lamp and buzzer and the A.D.T. connects by telegraph line to relays, sounder and register.

Circuits enter headquarters underground in six 40-conductor, two 50-conductor, one 60-conductor, and one 80-conductor lead-sheathed cables and terminate at the distributing rack in the basement. Panels are wired with asbestos-covered wire and are connected by open bus bars. Circuits are protected by ½-ampere, 2,500-volt enclosed fuses and double pole vacuum gap arresters at the operating boards and by 0.8-ampere, 2,500-volt enclosed fuses only at junctions of underground and aerial construction. Ultimate capacity of headquarters is about 100 box circuits.

Power Supply.—A 120-240-volt d.c. and two 220-volt, 3-phase a.c. circuits from the Pacific Gas and Electric Company are external power sources with a 7½-kw., 120-volt d.c. gasoline engine driven generator for standby service. Box circuits are supplied by individual vacuum tube rectifiers. Current for alarm circuits is supplied by a dynamotor for each 4 circuits. Dynamotors are supplied from the 120-volt, d.c. circuit with 120-ampere-hour battery floating.

A 2½-kva inverter, taking power from the 120-volt battery automatically on failure of a.c. power, furnishes energy for rectifiers. In case of failure

of d.c. power an automatic switch starts a 2¼-kw. motor-generator on the preferred a.c. service and connects its generator to the battery. Should the preferred a.c. source fail, another automatic switch connects rectifiers and, if necessary, the motor-generator to the second a.c. source. Current for local circuits in headquarters is supplied by a 10-cell battery under constant charge from the d.c. power circuit with a ½-kw., 25-volt motor generator, serviced by a.c. power, in reserve. Battery cells are well installed in a separate room.

Motor-generator sets are supplied also for 240-volt striking current over alarm circuits, for alarm circuit supervision, as an isolated source for routine circuit testing and for telephone ringing current. Emergency lights are supplied from the 120-volt d.c. bus.

Apparatus at Fire Stations and Elsewhere.—Duplicate alarm circuits connect fire stations, fire college, drill tower, pumping stations and at tanks of the high pressure system entering underground, terminating in each case in a recess behind a wooden panel upon which are mounted numbered test switches, relays, 8-inch gong, 5-inch tapper, an ink register and a desk telephone. Registers are direct acting with separate coils, actuated by either alarm circuit, but gongs and tappers are operated through local 30-volt transformers and relays. The a.c. supply is supervised by relay, local battery and vibrating bell. Telegraph instruments are installed on local practice circuits in most fire stations. Bells, registers, or both, connected to primary alarm circuits, are provided at street railway and electric power houses and barns, 2 draw bridges, police stations, hospitals and various offices and residences of fire and electrical department officials.

Boxes.—Total number, 1,745, an increase of 201 since the previous report. Most boxes are of interfering type.

FIRE ALARM BOXES

Department of Electricity	1532
Pacific Fire Extinguisher Co.	93
Gamewell Co.	61
California Electrical Co.	36
Foote-Pierson Co.	9
United States	6
Universal Tool & Manufacturing Co.	4
Star	4
TOTAL	1745

Boxes of the Pacific Fire Extinguisher Company, 38 of Gamewell make and a few of other makes were originally of succession type; in some of these, non-interfering coils have been cut out. Most have starting handles under glass guard; a few have key under guard. Excepting those along the waterfront which have 3-digits, all have 4-digit code wheels numbered in accordance with zones and districts. All Pacific Fire Extinguisher boxes have a distinguishing second digit. Those connected to the underground system are mounted on iron pipe standards or wooden posts; elsewhere they are on available poles. Boxes are painted red, with white bands on standards or alternate white and red bands about supporting poles. Except for boxes along the waterfront no indicating lights are provided. About 222 boxes are connected with auxiliary circuits. Seven boxes are provided for temporary replacement purposes. They are timed to transmit signals at the rate of 4 blows a second.

Distribution of boxes is good in the congested value district, particularly along Market Street, with a box at each intersection for the entire length and additional boxes on the opposite side at practically all intersections from the waterfront to 11th Street. Along much of the waterfront there is a box for each pier. Distribution is good in the industrial, Marina and Western districts. In general, box distribution is good in the northeastern part of the city and fair in outlying districts. In the Richmond and Sunset districts, boxes are located at alternate intersections of odd numbered avenues so that no building is further than about 670 feet from a box, but no boxes are on even numbered avenues.

Circuits.—In service are 70 box, 11 primary, 11 secondary and 2 traffic warning circuits; 47 box circuits serve excessive areas, and 3 primary and 3 secondary alarm circuits are overloaded with 8 or 9 stations connected to each. Approximately 60 per cent of box circuits and 72 per cent of alarm circuits are in underground cables in signaling circuit ducts owned mainly by the telephone company with some owned by the city. About half of the cables have No. 16 copper wires with saturated fibre insulation; the remainder are partly Nos. 18 and 19 copper with impregnated paper insulation; recent installations are of No. 18 copper with latex insulation. Opposite sides of most circuits are run in separate cables. Eight box circuits and 6 alarm circuits are totally underground.

Overhead wires are mostly No. 12 with some No. 10 hard-drawn copper with triple braided weatherproof insulation, usually on the top cross arms of telephone and two feet above the bottom arms of combination poles, frequently crossed by or run parallel to high tension wires. Special insulation is used where circuits run through trees. Box leads are of No. 14 or No. 12 rubber-covered copper in conduit with weather cap at the cross arm and insulating joint above the box; ground wires are protected by pipe and soldered to galvanized rods driven 5 feet. In the congested value district circuits are extensively interlaced in groups of 3. In outlying districts circuits are interlaced in pairs only.

TELEPHONE SYSTEM.—Adjoining the operating room of the central office is a 2-position branch exchange, owned and maintained by the telephone company. In service are 24 trunks listed under the same number and divided between two exchanges. Four of the trunks are reserved exclusively for fire calls, and there is one unlisted trunk. Locals connect with fire stations, assignment office, pumping stations, at tanks of the high pressure system, offices of the fire chief, fire commissioners, division of fire prevention and investigation, chief and superintendent of the department of electricity, municipal shop, electrical shop, city hall and police exchanges, and others.

Red and green pilot lights on the telephone board indicate when signals are being transmitted over primary and secondary alarm circuits. There is a special pilot light on the key operator's telephone circuit, and a short wave receiver tuned to the radio transmitter. No provision is made for grouped calling or talking to fire stations. With certain exceptions persons inquiring for locations of fires are denied this information. A direct line from the operating room connects with the A.D.T. office. Each fire station has a private telephone line for use of company members.

OPERATION. — Routine and Maintenance. — Operators work 8-hour shifts alternating between key and relay positions; they have one day off in four. One telephone and two telegraph operators are normally on duty. During weekdays an electrician is on duty at the central office and two or more linemen are available for trouble service; at night and on Sundays a repair man is also stationed at the central office. A captain and lieutenant or two lieutenants of the fire department are on duty in the assignment office and, following third alarms, a battalion chief.

In addition to transmitting alarms and numerous routine signals, operators receive and record box tests, direct the work of clearing circuit troubles, check operation of the police radio transmitter and the automatic timing of street traffic signals. Circuits are tested for grounds and crosses at each change of shifts, and ground tests for each box circuit are made following each box test. Line current and voltage are not noted unless insufficient to operate relays. Test signals are sent over the system 3 times daily. Operators keep records of all alarms and troubles, preserve sections of box register tapes and record boxes tested and the time for each.

All department members are subject to call for emergency service. Line materials are stored at the department shop on Golden Gate Avenue near Hyde Street. Replacement boxes, station instruments and a small amount of line repair materials are kept at the central office. A lineman responds to all second alarms in a truck equipped with radio receiver, and the superintendent to third alarms. A lineman is assigned to the testing and adjustment of all fire alarm boxes; all were tested five times during 1947.

Alarm Transmission.—Signals from box circuits are manifested by winking pilot lights, telegraph sounder, and ink register and the circuit operating is indicated by illuminated box list. Following the second round of a box, operators check the number, and the key operator, using a telegraph key, transmits two rounds of the signal successively over each class of alarm circuts, starts the radio transmitter and announces the box number twice. If fire apparatus is required to cross Market Street, traffic signal bells are operated from 2 to 5 minutes. Operators are not given authority to hold up box alarms even though obviously for the same fire; such alarms are transmitted to fire stations, there to be interpreted by company members.

Telephone alarms are switched by the telephone operator to the key operator, who consults a telephone response book to obtain the nearest fire company and street box, and transmits the box number over alarm circuits and radio. For a telephone alarm reported to be a fire of minor importance, only the nearest company and battalion chief are notified by telephone and struck out of service by coded signals over secondary alarm circuits, and the location is broadcast by radio. For alarms received verbally at fire stations the same procedure as for telephone alarms is followed. A.D.T. alarms of fire are received and transmitted in the fire alarm numbering code; for sprinkler supervisory calls from the A.D.T., the nearest company is dispatched by telephone.

Movements of companies are followed on a large scale map by the assignment officers, who may order additional movements to protect uncovered districts when the usual assignments fail to leave suitable company distribution. Company officers report their return to quarters by telephone. Company in- and out-of-service signals are given in coded numerals; outside test signals and brief fire reports are in telegraph code.

The total number of first alarms during 1947 was 12,053. Of these 3,588 originated at street boxes, 6,587 by telephone, 1,778 were verbal and 100 were A.D.T. alarms; 130 were from Reichel systems, 104 were second alarms, 30 were third alarms, 5 were fourth alarms and 3 were fifth alarms. False alarms from street boxes totaled 1,462.

CONCLUSIONS.—Boxes are in general well distributed, but most are of an obsolete interfering type which, in combination with overloaded circuits, tend to make receipt of alarms uncertain. Circuits are reasonably well maintained, but many are heavily overloaded and unnecessarily long as a result of extensive interlacing. Operation of

the system is dependent to an unusual degree upon the personal element; the fairly high degree of reliability attained is largely due to skill and diligence of the operating force. Routine signals should be handled by telephone over the circuits without, as at present, interfering with box alarms.

Although nine circuits have been added, the overloaded condition of circuits and office equipment continues in about the former proportion. Installation of modern equipment and inauguration of improved operating methods are needed to provide the necessary capacity and reliability.

FIRE DEPARTMENT AUXILIARIES

FIRE MARSHAL. — State. — Joe R. Yockers was appointed State fire marshal in May, 1943, following an experience of eight years in the Alhambra, California, fire department, eight years in the fire marshal's office where he rose to be deputy in charge of the Los Angeles office and one year with the United States Navy. He is charged with adopting and enforcing minimum standards for the prevention of fire and protection of life and property. To advise him in this capacity, a State Fire Advisory Board is established, consisting of fire officials from various parts of the State. Power is given to enforce the State regulations outside of corporate cities and fire protection districts and within these areas if requested. Total male personnel, including a fire prevention engineer and a chemist, numbers 29, distributed among the three offices in Sacramento, Los Angeles, and San Francisco.

Municipal.—The Chief of the Division of Fire Prevention and Investigation performs the duties of fire marshal. Powers and duties are specified in various ordinances dealing with suppression of arson and control of fire hazards. Frank P. Kelly has been fire marshal or chief of the division since 1926. A complete card record is kept of all persons involved in fires of suspicious origin. During 1947, there were 1,205 fires investigated, 95 of which were of unknown origin or incendiary. Eight out of nine persons were convicted of felony and 54 out of 68 were convicted of misdemeanor; 140 juveniles were returned to their parents after the parents were admonished.

POLICE DEPARTMENT.—Chief, Michael E. Mitchell; total membership, 1,534; uniformed force, 1,428. The department is divided into 12 companies including inspector's bureau, traffic bureau, and headquarters, assigned to 9 districts.

Eight patrol wagons carrying stretchers and rope are distributed about the city. There are 135 automobiles, 5 trucks, 114 motorcycles that are equipped with radio receivers; 84 automobiles have 2-way radio. Present central transmitter is of 400-watt rating on a frequency of 2,466 kc.; fire department box alarms are broadcast in addition to police matters. Delivery is expected within 2 months of a more powerful transmitter with complete standby facilities, at which time the fire department will be operating over a completely independent system. No difficulty has been noted from both services using the one transmitter. The teletype system consists of one State and two local transmitters, and 15 receivers.

Each district has a signaling system maintained by the department of electricity. There are 30 separate circuits with up to 57 telegraph and telephone boxes on a circuit, with a total of 395 boxes. All calls come to a central panel board enabling any connection to be made from the outlying boxes. Patrolmen report every 2 hours.

A radio-equipped patrol car with two officers attends all first alarms and a district patrol sergeant also responds. Alarms in the vicinity of hospitals or schools receive the response of two patrol cars. On the judgment of the patrol sergeant additional officers are ordered and fire lines are maintained.

PUBLIC SERVICE CORPORATIONS.—The division operator of the gas and electric company has a punch register in his office and dispatches trouble men on second and greater alarms, or on first alarms if requested. Trouble men report to the officer in charge of the fire and are equipped to cut wires, shut off gas, and to perform other similar emergency duties. Telegraphic fire alarms are received at the line department office of the street railway system, and alarms are received by radio except during a brief interval at night. An emergency repair crew with truck responds to second or greater alarms equipped to shift or remove trolley wires and feeders.

TELEPHONE SERVICE.—The Pacific Telephone and Telegraph Company serves about 261,200 subscribers in San Francisco and including a small portion of adjoining San Mateo County. In this area about 406,100 telephones are installed connected to single- and 2-party lines through 35 exchanges in 12 central office buildings; 29 exchanges are dial-operated. Forty-eight per cent of the lines, including all business lines, are one-party lines. The congested value district is served by 6 dial-operated exchanges which are in a 7-story telephone office building of fireproof construction, located at Bush Street near Kearny Street. Except for the small brick Chinatown exchange, central office buildings are of fireproof construction, as well as two under construction. Exposed openings are protected, extinguishers, sand and water pails distributed, boards protected by asbestos blankets and, in some buildings, standpipes with hose are provided. About

84 per cent of the total conductor mileage is in underground cable and the remainder in aerial cable. Fire alarm headquarters is connected to two dial-operated exchanges in buildings of fireproof construction located near Market and Valencia Streets and at Steiner and Pine Streets. Service from one exchange is over 25 trunk lines and from the other, 2 trunks and 2 one-party lines. Subscribers are directed either to dial the fire department number or to dial for the operator when reporting fires. Fire calls handled by the operator are supervised and recorded. Of the 12,053 first alarms received during 1947 about 55 per cent were transmitted by telephone.

CENTRAL STATION WATCH SERVICE.—The American District Telegraph Company furnishes fire alarm, night watch and sprinkler supervisory services to a total of 412 subscribers. Of these, 142 have sprinkler supervisory service, 91 have automatic fire alarm, 16 have both, and the remainder have either manual fire alarm or night watch, or both. The central office is on the second floor of a 7-story building of fireproof construction in the congested value district, of multiple occupancy, with unprotected vertical openings. The office has proper fire extinguisher distribution and is protected by wired glass against exterior exposures but is exposed across a light court by other occupancies in the building. From 4 to 9 operators are on duty. Circuits are largely underground in leased wires of the telegraph and telephone companies. Current is available from rectifiers, storage batteries, and from a direct current power circuit supplying the business district; emergency lights are provided. Alarms are received on standard A.D.T. equipment and transmitted to the fire department as a number designating the particular property protected. A.D.T. records for 1947 show 240 alarms transmitted to fire alarm headquarters of which 128 were false or were caused by undue heat; 45 originated by night watch or fire alarm circuits, 131 by sprinkler supervisory, and 64 by Aero systems.

AUXILIARY FIRE ALARM SYSTEMS.—Fire Detection Service (Reichel System) serves 94 subscribers in mercantile and industrial risks with auxiliary alarm systems of the Pacific Fire Extinguisher Company with transmitters connected in municipal box circuits. Transmitters have double code wheels giving separate signals for fire and trouble. The company is notified by fire alarm headquarters of all alarms affecting their systems and has maintenance men to restore systems to normal. Records of the company for 1946 show 11 fires detected automatically, 32 alarms transmitted manually for vicinity fires, 52 false alarms, and 85 trouble alarms.

The Pacific Auxiliary Fire Alarm Company protects about 400 premises with a total of 1,811 Gamewell auxiliary boxes connected with 215 street fire alarm boxes. Current is supplied by batteries in cabinets attached to poles or standards of street boxes. No means are provided to indicate which building is affected where several different installations are connected to the same street box.

PRIVATE FIRE APPARATUS.—A fire department survey made in 1941 showed 600 private tanks and cisterns distributed throughout the city with individual capacities ranging from 5 to 100 thousand gallons; total capacity 13,607,000 gallons. All have suction connections for pumpers. Several boats and tugs in the harbor have fire fighting equipment including 2 State-owned tugs with pumps of about 1,500 gallons capacity. None of these are on a standby basis, but will respond if available.

OUTSIDE AID.—The fire department is of such size that it is unlikely to need outside assistance. For the Treasure Island fire of April 10, 1947, requiring 62 units of San Francisco equipment, 4 companies from Oakland responded. There is little likelihood of calling in equipment for city aid, although companies from the East Bay cities could respond within one-half hour of call.

STRUCTURAL CONDITIONS AND HAZARDS

BUILDING DEPARTMENT

ORGANIZATION.—General.—The Bureau of Building Inspection is part of the Department of Public Works, under the general supervision of the Director of that Department and in direct charge of a Superintendent. Permits are issued and most records are kept by the Central Permit Bureau, a part of the same Department. Employees of both bureaus are appointed under civil service provisions.

Personnel.—Since resignation of John G. Little on February 1, 1948, his assistant, George W. Marsh, has been acting Superintendent of the bureau of building inspection. Civil service examinations to fill the position will be held in May, 1948. Bureau personnel includes 3 engineers, 18 building inspectors, 2 boiler inspectors, and 3 clerk-stenographers.

Permits.—The Central Permit Bureau, a clerical organization, receives applications for permits to construct, alter or demolish buildings and

for other construction activities. Applications must be accompanied by plans and specifications and are referred to the several bureaus or departments having jurisdiction before a permit is issued. Construction permits require approval at least by the bureau of building inspection, division of fire prevention and investigation, and city planning commission. Certificates of occupancy are issued by the central permit bureau for residential occupancies, and certificates of final completion are issued by the bureau of building inspection for other occupancies. A Board of Permit Appeals, established by city charter, is empowered to hear protests against the decision of any department authorized to issue permits or licenses and to revoke or uphold such decision. The Board acts mostly on cases involving alterations rather than new construction.

Inspections.—Engineering features of plans and specifications are checked by the structural engineers, who also make field inspections when necessary. Three building inspectors, one a plan checker and the others acting in a supervisory capacity, spend most of their time in the office.

For inspection purposes the city is divided into 15 districts with an inspector assigned to each. Number of inspections made per building depends upon the size and type of construction; for the average building inspections are made of foundation forms, foundations, framing, lathing and plastering, chimneys and flues, and finish. Verbal orders are usually given to correct any defective construction. Each inspector keeps a record of inspections made and of any corrections ordered.

Records.—Records kept are very complete, filed in convenient form and cross-indexed. They include applications; copies of permits; copies of certificates of occupancy and final completion; record cards filed by number, location and owner's name; and inspector's field notes. Plans are kept in the bureau offices for a certain length of time, then filed permanently in a plan room in the basement.

LAWS AND ORDINANCES. — State. — The State Housing Act, extensively amended in September, 1947, deals with health, sanitation, and fire safety in hotels, apartment houses, and to some extent in dwellings. Important revisions and additions have been made concerning exits, and stairways in buildings over two stories high must now be enclosed within at least metal lath and plaster construction, with self-closing fire doors at openings.

Automatic sprinkler systems are required in basement storage rooms used for combustible materials and in any basement room of over 1,800 square feet. Dry standpipes are required in buildings over 3 stories high and wet standpipes, in buildings over 2 stories. Fire extinguishers are required in specified numbers in hallways, garage sections, and rooms used by the public. Except in smaller buildings, fire alarm systems are required for the warning of occupants. Reference is commonly made to the standards of the National Board of Fire Underwriters and Underwriters' Laboratories for the construction and installation of fire protective equipment. Decorative materials used on walls, ceilings, and elsewhere in rooms of public occupancy and in hallways and stairways must be incombustible or properly treated with flame-retardant chemicals. There are provisions covering building heights, fire escapes, firestopping, enclosure of heating equipment, and segregation of sections used for automobile storage and the storage and handling of paint materials. The Riley Act requires, with few exceptions, that all new buildings be designed to resist a certain degree of horizontal force due to earthquake.

Enforcement of these laws is largely dependent on supervision by municipal authorities.

Municipal.—The old building code was replaced on September 11, 1947, by a completely new code patterned in part after the Uniform Building Code of the Pacific Coast Building Officials' Conference, and with certain provisions carried over from the previous San Francisco code.

Types of construction are divided into five main groups: Type 1, fire resistive, which includes Type 1-A, protected steel frame, and Type 1-B, reinforced concrete; Type 2, heavy timber, Type 3, ordinary masonry; Type 4, light incombustible frame; and Type 5, wood frame. Type 1 construction must have 4-hour fire resistant exterior walls but may have 3-hour interior frame and from 3- to 2-hour floors and roof, depending upon occupancy. Fire resistance ratings assigned to various assemblies are similar to those in the Uniform Building Code and are inaccurate in a few cases.

Occupancies are divided into 9 classes consisting of theatres, public assembly units, schools, institutions, hazardous use units, business units, non-hazardous use units, residential units, and a miscellaneous class. The class of occupancy determines many of the code requirements.

For the first time, special building code requirements are given on the design of structures to resist earthquakes. Buildings must be designed to resist earthquake or wind forces, whichever are greater. Wind forces are assumed to be 15 pounds per square foot for buildings up to 60 feet in height and 20 pounds for buildings over 60 feet. For earthquake design the formula $F = CW$ is used, in which F is the horizontal force to be resisted, C is a coefficient, and W is the total dead and live column design load at and above the plane under consideration. For design of the structure as a whole, values of C are successively reduced for each story, starting downward from the roof; C is .080 for the top-story

of a building and is .037 for the lowest story of a 30-story building. In addition higher values of C are given for walls, ornamentations, towers, and other parts of a structure. The value of C is increased in general by 25 per cent for structures on marshy or filled ground and is reduced by 15 per cent when on rock.

Building heights are limited according to type of construction, occupancy, and district of the city. Type 1-A buildings are unlimited and Type 1-B, limited to 10 stories. Height limits are liberal for buildings of business, non-hazardous, and residential occupancies. These may be 7 stories and up to 84 feet if in Type 3 buildings having incombustible frame and interior construction of one hour fire resistance. Buildings housing these occupancies may be 3 stories high if of Type 5 construction. These limitations become even more liberal because of the local custom of excluding from the meaning of story height the grade story of residential buildings when used for garage purposes.

Areas are limited according to type of construction, class of occupancy, story height, and number of streets bounding the building. Allowable areas are generally somewhat excessive and are particularly large for certain 1- and 2-story buildings. These may be as large as 20,000 and 30,000 square feet when of Types 2 and 3 construction and housing non-hazardous use units and business units not used for storage. One-story buildings of Type 5 construction may be up to 12,500 square feet if housing business units having not over 30 pounds per square foot of combustible contents. The code requirements for fire resistant separations between certain occupancies tend to reduce the fire areas in buildings of mixed occupancy.

Wall openings in all buildings in the fire limits must be protected against fire exposure when 20 feet from property lines, from other buildings, and when on streets less than 50 feet wide. Outside the fire limits, exposure protection is liberalized or eliminated for Types 4 and 5 buildings. Reference is made to protectives labeled by Underwriters' Laboratories and to the standards of installation of the National Board of Fire Underwriters.

Practically all vertical openings are required to be enclosed within 1- or 2-hour fire resistive partitions, with openings in exit enclosures protected by labeled doors for Class "B" openings. Shafts, ducts, and other vertical openings of 9 square feet or smaller may be enclosed by sheet metal, spaced away from combustible construction or otherwise protected. Enclosures are not required in non-hazardous use buildings for vertical openings that are not used as exits nor for escalators in sprinklered Type 1 buildings of business or non-hazardous occupancy.

The code does not mention communicating openings between buildings and between fire areas, except in the case of mixed occupancy. Certain occupancies must be separated by 4-hour unpierced walls and others, by 3-hour walls with double Class "A" fire doors at each opening. It is the building department practice to continue use of the former code provision permitting communications between fire areas if protected by double, automatic fire doors.

Unpierced walls are required within specified distances of property lines, distances ranging up to 10 feet, depending on the occupancy. Required thicknesses of masonry and reinforced concrete walls are generally good, but thicknesses of fire walls are governed only by use as a bearing or non-bearing or as a party or non-party wall. Parapets 2 feet in height are required on exterior and inner court walls of Types 1, 2, and 3 buildings except when the roof pitch exceeds 6 in 12.

Fire stopping is required in exterior and interior wood stud walls, in furred masonry walls, in spaces around chimneys and framing, spaces around pipes and ducts, and in other essential locations. Attic spaces in non-fireproof buildings must be subdivided by tight board or incombustible partitions into areas not exceeding 2,500 square feet.

Requirements on chimneys and heating equipment are in some respects unconventional and peculiar to this locality. Masonry chimneys must be 8 inches thick or 4 inches if flue-lined. Only chimneys outside of walls must be built from the ground up. Patent fireplaces are permitted, constructed of masonry built on wood floor joists, the fireplace being supported on a ¼-inch iron plate topped with 1 inch of concrete or mortar followed by a course of brick. Patent chimneys may be used in place of masonry, except for certain oil burner installations, and must be constructed of 24-gauge metal around 1-inch clay pipe, with a 1-inch ventilated space between; support may be an outside iron bracket or an interior wooden floor protected by 8 inches of masonry. Gas vents and flues are well covered. Fairly good requirements are given for gas- and oil-burning warm air furnaces and other appliances; clearances from appliances and from vents and flues to woodwork are fairly well handled. Boilers, furnaces, and water heaters burning fuel other than gas must be enclosed in rooms having masonry walls, metal lath and plaster ceiling, and automatic fire doors at openings.

Means of egress are well covered. In addition to required exits of a standard type, fire escapes are required for buildings over 2 stories high, the number depending upon the area of the building.

Automatic sprinkler systems are required on theatre stages, in woodworking plants, mattress and upholstery plants, film exchanges, in hazardous storage and work rooms of hotels and apartments, in basement storage or work rooms in pub-

lic assembly and school buildings, in most cellars that exceed 1,500 square feet area and are less than 3 feet above grade, on floors at or below street level in stores having combustible stocks and exceeding 20,000 square feet in area, and in any building having its street front of construction that might hinder fire department operations. Standards of the National Board of Fire Underwriters on sprinkler equipments are adopted, with a few amendments including acceptance of a single source of water supply.

One or more dry standpipes for fire department use are required on each building 4 stories and higher, and interior wet standpipes with hose connection at each floor are required in all buildings exceeding 58 feet in height. Buildings over 124 feet high must have special water supplies to standpipes. Inlets for use of cellar pipes are required in floors over basements used for storage.

Fire retardant roof coverings are required throughout the city.

Fire Limits.—The main fire limits, covering 1,500 acres, remain unchanged and are shown on the accompanying map. They include practically all of the congested value district, some of the waterfront and industrial area, and a small part of the apartment house districts. A smaller fire limits, covering about 51 acres, includes the minor mercantile section along Fillmore Street.

New frame construction is prohibited within the fire limits. Frame buildings suffering fire or other damage exceeding 50 per cent of their assessed valuation may not be repaired but must be removed.

Enforcement.—The building code has not been in effect long enough to evaluate enforcement. Most of the several large buildings under construction and recently built, the plans of which were substantially completed when the code was passed, were permitted to comply with the provisions of the previous code, a document deficient in many respects from a fire control standpoint. Wartime housing projects and some industrial buildings built under war emergency conditions and still in use were erected in violation of certain code requirements.

LOCAL CONDITIONS. — General. — The limited land available for building sites within the limits of the city is reflected in the general lack of side yards in residential areas and the use of multi-story buildings in apartment and flat districts. Predominant use of wood over a long period has created high concentrations of combustible construction in compactly built blocks. Heights of hotels and apartments reach 5 stories for frame and 7 stories for ordinary construction, plus one or more additional stories for buildings with grade-level private garages and for buildings located on the many steep slopes. Unenclosed stairways, elevator shafts, and light courts permit rapid involvement in fire of stories above the floor of origin, and barriers to prevent the horizontal spread of fire are likewise lacking. Fire escapes of the usual steep, narrow type are generally provided, and heavy reliance is placed upon quick response of the fire department to rescue occupants. Delay in discovery of fire or in sounding the alarm can be expected to produce heavy life loss. Buildings involving high hazard are especially numerous in the Western Addition and Mission districts. Some improvements have been made by construction and alteration work done in accordance with recent State legislation; the law, however, is not retroactive, and the general level of safety to life in residence occupancies has not materially improved.

In the city are schools, hospitals, old people's homes, and other institutional buildings of wood frame construction two to four stories high. Efforts are made to limit the use of upper stories to able-bodied persons or to storage purposes; this reduces but does not always eliminate the hazard, which in some buildings is very high.

Congested Value District. — The congested value district as outlined consists of 185 blocks which include 2,329 buildings, 411 of which are of fireproof construction, 1,856 of ordinary masonry, and 62 of frame construction, besides 52 frame sheds or additions.

Fireproof construction covers 34 per cent of the built-on area; 222 buildings are of the protected steel frame type and the remainder of reinforced concrete. Structural members of the steel frame buildings are generally protected by concrete fireproofing, although a few of the older structures make use of metal lath and plaster or tile fireproofing. Floors and roofs are practically all of reinforced concrete construction, 3½ or 4 inches in thickness. A few of the older steel frame buildings have self-supporting exterior masonry walls; panel walls supported at each story are mostly 12-inch brick or 6-inch reinforced concrete. Buildings of reinforced concrete construction usually have 6-inch concrete panel walls. Four buildings of fireproof construction have wood roofs over top story fireproof ceilings; a few also deviate from full fire-resistive construction in other respects, such as use of wood partitions and unprotected or plaster-protected roof trusses.

Of the buildings of fireproof construction, 175 are of bank or office occupancy, about half of them with grade floor mercantiles; 120 are of mercantile or loft occupancy, 53 are hotels or apartment houses, 22 are garages, 13 theatres, and the remaining 28 of miscellaneous occupancy. Areas are generally moderate; 250 buildings are less than 10,000 square feet in area and 161 exceed this area; 30 of the latter are sprinklered. Twelve exceed 40,000 square feet, the largest being a 2- and 3-story railway terminal building

of 140,000 square feet, which has some unprotected steel work. A 4- to 9-story sprinklered department store is 99,100 square feet, and a 9-story hotel covers 88,400 square feet. Sixty-one per cent of the buildings are 6 stories or over in height; 52 of these are 12 to 20 stories and 9 exceed 20 stories.

Floor openings are completely protected in less than 10 per cent of the buildings of fireproof construction; in the older structures both elevator shafts and stairways are generally without enclosures. In the newer buildings elevator shafts are usually enclosed but stairways are open except where serving as required exits in large buildings. Exposed windows are completely protected in only 33 per cent of the buildings requiring such protection. Forty-three buildings of fireproof construction, covering 16 per cent of the area occupied by this type, are protected by automatic sprinkler equipment. Few buildings are designed to withstand horizontal stresses beyond those due to moderate wind pressures. Several underground storage garages have been constructed, the largest one, a full block in area, being located under Union Square.

Ordinary masonry buildings, including a few of heavy timber and similar construction, cover 65 per cent of the built-on area. Sixty per cent of these buildings are from one to three stories in height, 16 per cent are four stories, 10 per cent five stories and 10 per cent six stories; 77 buildings of non-fireproof construction are 7 stories or over in height. Fifty-two per cent of the total area occupied by ordinary masonry construction occurs in unsprinklered fire areas which exceed 5,000 square feet and 17 per cent in fire areas which exceed 10,000 square feet. Nine areas exceed 20,000 square feet, the largest being a sprinklered 4-story mercantile and department store building of 60,900 square feet, divided into two sections by a good fire wall with double fire doors on openings. Approximately one-fourth of the buildings of ordinary construction have reinforced concrete enclosure walls, usually six inches in thickness. Frames of reinforced concrete or of unprotected or partly protected steel are found in a fair proportion of the non-fireproof buildings, particularly those of four stories and over. Many public garage buildings exceeding one story in height are of fireproof construction except for wooden roofs and roof framing.

Frame construction within the district covers less than one per cent of the built-on area. While old wooden buildings have been removed, all-metal construction has been erected for filling station buildings and for 1-story open-sided storage and automobile sheds. A few wood frame buildings exceed 2 stories. Areas are mostly small, the largest being formed by two groups of 3-story apartment buildings totalling 10,100 and 10,200 square feet.

Including all classes of construction, the proportion of buildings having unpierced masonry or reinforced concrete exterior walls is moderately large and such walls are generally of adequate thickness. Party walls are not used to any marked extent. Parapets average from two to three feet in height. Floor openings are adequately protected in only 6 per cent of the total number of buildings requiring such protection. Exposed windows are protected in only 309 buildings and partly protected in 264 others, out of 2,049 buildings exposed within 50 feet; protection consists almost entirely of wired glass in metal frames. Communicating openings between buildings, which have increased to 236, have a fair amount of protection; 93 have standard protection and 79 have single doors or double non-standard doors. Skylights are practically all of wired glass, including those over vertical shafts.

Complete automatic sprinkler equipments are installed in 90 buildings, and 26 other buildings have partial installations, chiefly in stage sections of theatres or in basements. Ten per cent of the total built-on area is occupied by sprinklered buildings, almost two-thirds of which are fireproof. Dry standpipes, generally installed at fire escapes, are provided on 1,003 buildings, including most of those 4 stories or over in height. Inside standpipes and hose are provided in 703 buildings. Fire escapes are provided on practically all of the non-fireproof buildings four stories or more in height and on most of the three-story buildings; a few of the latter and some buildings of fireproof construction do not have this means of egress. The narrow, steep stair and balcony type is commonly used, generally exposed by unprotected windows and frequently lacking access to the ground from the lowest balcony.

Means of egress and structural conditions are especially hazardous to life in the compact blocks of high apartments and hotels in the western third of the district. Combustible interior construction without fire cut-offs vertically or horizontally, severe mutual exposure between buildings across unprotected light courts, and the problems of rescue created by poor accessibility to block interiors and by sloping ground combine to create a very serious hazard.

CONCLUSIONS.—Passage of the new municipal building code has been a progressive step toward securing greater fire safety and better fire spread control. Certain features remain deficient, such as the excessive heights permitted for residential and some other buildings and excessive areas for certain occupancies. With good enforcement, construction under the new code can be expected eventually to raise the general level of safety from fire, but this undoubtedly will take considerable time, since laws are not retroactive. Meanwhile, a very severe hazard to life exists in the highly combustible apartment and hotel districts

and in certain institutional buildings, where such heavy reliance is placed upon fire department rescue work that when this is not immediately forthcoming, heavy life loss can be expected.

The fire limits include most of the congested value district but do not include enough of the minor mercantile and closely built apartment house sections which expose this district. Outside of the main fire limits, only one minor mercantile district is protected by fire limits. Fire retardant roof coverings are required throughout the city. In the congested value district, fireproof construction and sprinklered ordinary masonry buildings cover 38 per cent of the total built-on area; the remaining area is very closely built with ordinary masonry construction, much of it of excessive height and having very few structural features tending to restrict the spread of fire.

FIRE PREVENTION

ORGANIZATION.—Supervision.—A fire prevention force, first established in 1920, has been reorganized at various times and since 1937 has been the Division of Fire Prevention and Investigation. General supervision over the Division is delegated by the Fire Commission to the Chief of the fire department, and direct control is exercised by the Chief of the Division. In addition to having general powers dealing with the manufacture, storage, handling, and use of explosive or flammable substances, the Division is charged with the suppression of arson.

The Board of Permit Appeals, established by city charter, is empowered to hear protests of citizens and to revoke or uphold decisions of the Division. Members of the 5-man board appointed by the Mayor are business men.

The State Fire Marshal's office maintains a force of men for enforcement of the State acts regulating dry cleaning plants, sponging and spotting establishments, and inspection of institutional and public assembly buildings.

Personnel.—F. P. Kelly has been Chief of the Division of Fire Prevention and Investigation since February, 1937. He is assisted by Captain T. Trivett, in charge of fire prevention activities. Engaged in fire prevention work are 5 lieutenants, 23 field inspectors, and 4 office men. Fire investigation work is handled by a lieutenant and 7 men.

Fire prevention personnel is limited by the fire code to 2 per cent of the fire department membership; however, the City Charter, which takes precedence, permits the appointment by the Fire Commission of as many men as deemed necessary. New inspectors generally receive their training by accompanying experienced men on inspection work. A considerable number of inspectors have had only 1 or 2 years' experience in fire prevention work. Transportation for fire prevention personnel is provided by only three automobiles. Fire department civil service rules are in effect.

Permits.—Permits from the Division of Fire Prevention and Investigation are required for oil burners, explosives, storage of nitrocellulose and film, storage of carbide, acetylene generators, and the storage of petroleum products. Permits renewable annually are required for petroleum tank trucks and paint spray shops. Permits from the fire department, signed by the chief, are required for the establishment of garages, service stations, automobile repair shops and sales garages, dry cleaning plants, and for burning rubbish. All applications, including those made to the fire department, are reviewed and the installation inspected by the Division of Fire Prevention and Investigation. Applications for building permits submitted to the Bureau of Building Inspection require approval by the Division, and applications for some other permits and licenses, made to various municipal departments, are referred to the Division for investigation and recommendation when fire safety features are involved.

Inspections and Activities.—A lieutenant and two inspectors of the Division of Fire Prevention and Investigation are detailed to work mornings with the Bureau of Building Inspection in checking plans for new construction and alterations to see that regulations on safety from fire are observed; they make field inspections in cases where special problems of safety may be involved. Three lieutenants act mainly in a supervisory capacity, assisting the district inspectors in their work.

An inspector is assigned to each of the districts into which the city is divided for inspection purposes. Each man follows up the building permits issued for his district, checking such items as exits, private fire protection, installation of heating equipment, fireplaces and flues, garage separation, and other similar features. Other work consists of investigating complaints, which take considerable time, and making inspections in connection with issuance and transfer of permits and licenses. Special inspection drives are made at times to detect and correct hazards in certain occupancies, which have included bulk oil plants, night clubs, theatres, and schools. Except for a recent 4-month drive on slum conditions in a section of the Western Addition, only a very limited number of systematic block-to-block inspections are made. When unsatisfactory conditions are found, a written notice or letter is sent to the owner and a reinspection made after a specified time. Legal action is occasionally necessary and citations to show cause why a warrant should not be issued are used with moderate frequency.

Because of limited personnel and the time taken up by other duties, very little activity in the nature of publicity, educational, or public relations work is done.

Battalion chiefs inspect a variable number of buildings in their respective districts each month, forwarding reports on conditions found to the Division for any action necessary. Men detailed from nearby fire stations make brief visits daily to motion picture theatres; in case of legitimate stage productions a fireman is on duty at all times during the performance. Inspections of night clubs are made at night by chief officers. Crews under the direction of a battalion chief are sent out at times to burn off dry vegetation from vacant lots.

Records.—Complete records are kept of inspectors' notes, corrections ordered and compliance secured in connection with new building construction and alterations. Copies of permits issued by the Division and by the fire department are filed, as well as recommendations made in connection with permits issued by other departments. Inspection forms are filed on bulk oil plants, night clubs, theatres, and other occupancies inspected as a group or individually. Daily record is kept of the work of each man. Monthly reports of the activities of the Division are compiled, but no annual report is published.

Inspection reports in general have a card reference file arranged by street and number, and all reports, permits, and other data pertaining to one building are kept together in a folder. A pending file is kept which contains unfinished reports that require follow-up work, indexed to insure reinspection on the proper date.

LAWS AND ORDINANCES.—State.—The Health and Safety Code of 1945 contains a compilation of laws a number of which deal with fire safety. Requirements are given for the sale, transportation, and storage of explosives, including a Quantity and Distance Table and specifications for magazines; a book record of sales must be kept by dealers. The manufacture, storage, and sale of fireworks must be under permit from local authorities and the sale and discharge of those types designated as dangerous are prohibited except for authorized public displays.

The design and equipment of all dry cleaning plants are subject to the approval of the State Fire Marshal's office. By a 1947 amendment, solvents with flashpoint lower than 100°F. are prohibited. Plants using solvents of between 100° and 138.5° are under good, detailed requirements covering construction, equipment, fire protection, and handling of solvent. Those with solvents of higher flashpoint are subject to somewhat less restrictive, but adequate regulations.

The State Fire Marshal, with advice of the State Fire Advisory Board, is charged with adopting minimum standards for the prevention of fire and protection of life and property. Power is given to enforce the State regulations outside of corporate cities and county fire protection districts and within these areas if requested. Authority is given to make and enforce regulations covering exits and fire hazards in State institutions. Tents used for public gatherings must be flameproofed and must be arranged and protected to prevent fire and panic according to the standards of the State Fire Marshal. Portions of the Uniform Building Code of the Pacific Coast Building Officials' Conference affecting public assembly and institutional buildings and places of entertainment are included in the California Administrative Code and are used as a guide in safeguarding these occupancies. Decorative materials in public places where people gather must be incombustible or treated to make them flame-retardant; flame-retardant chemicals and fabrics are regulated by detailed standards of performance and must successfully pass a test by an approved laboratory. Standards and tests are authorized and have been developed for the regulation of flammable wearing apparel.

The State Housing Act prohibits gravity feed of liquid fuel in hotels and apartment houses. Storage garages in hotels and apartment houses must be cut off from the remainder of the building by partitions and ceilings, the construction of which depends upon the area enclosed, ranging from metal-covered wood to 8-inch masonry walls and 3-inch masonry ceilings; openings must be protected by metal-clad doors. Public garages or automobile repair shops are not permitted as part of apartment houses or hotel buildings unless properly cut off. Every gas service to an apartment house, hotel, or dwelling must be provided with an outside shut-off valve. Requirements cover vents and flues for gas appliances, and appliance gas supply must be through approved metal piping.

The State Division of Industrial Safety has adopted many sets of safety orders, which cover places of employment and some of which deal with fire safety, particularly as applying to safety to life. The Electrical Safety Orders contain requirements for the construction of motion picture projection booths, for the equipment contained therein, and for wiring in hazardous atmospheres. The Liquefied Petroleum Gases Safety Orders, revised January, 1946, contain good regulations on storage and handling of the gas. Safety orders on Petroleum cover drilling, refining, storage, and handling.

Municipal.—The Fire Code, amended to March, 1947, is a compilation of fire prevention ordinances, which are fairly effective but some of which are obsolete or contain contradictory or ambiguous provisions. Regulations governing specific fire hazards are enforceable by various municipal departments such as the fire department, bureau of fire prevention, board of public works, health department, or police department. Hazardous conditions endangering life or property and not regulated by law may be declared a nuisance, and abatement action is authorized.

Regulations on wholesale storages of petroleum products are very brief, requiring mainly that tanks must be constructed and protected as required by the Fire Marshal, now the Chief of the Division of Fire Prevention and Investigation. Such storages or distributing plants are allowed within specified industrial districts only. It is not clear that refined petroleum products other than those with a flashpoint below 110° F. come within the scope of these regulations. Gasoline, defined as any product of petroleum with a flashpoint below 110° may for retail sales or ordinary use be kept aboveground in approved 50-gallon portable tanks. Quantities of gasoline in excess of these must be stored in underground tanks of relatively small capacity. Approved dispensing pumps must be used. Flammable liquids other than petroleum products are not mentioned. Good requirements are given on the construction and equipment of tank trucks.

Storage and use of fuel oil must be under conditions satisfactory to the Fire Marshal; aboveground storage, and gravity or pressure feed to burner is not allowed. Approved burner equipment must be used and unless an attendant is on duty at all times suitable automatic devices to prevent abnormal discharge of oil at the burner are required. Requirements on furnace rooms, chimneys, and flues are given in the building code.

Public and commercial garages, filling stations, and automobile repair shops are subject to generally good regulations for construction and maintenance. Sections devoted to automobile repair, painting, or tire vulcanizing must be cut off from storage sections of the garage by fire-resistive partitions. Storage garages in hotels, apartment houses, or under places of public assembly must have adequate fire separation from other parts of the building.

Provisions on paint spray shops have been adopted and require fire retardant construction, fan ventilation, approved electrical equipment, and fire extinguishers. Smoking and open flames and sparks are prohibited. Poor conditions in existing shops may be corrected by withholding the required yearly permit if shop conditions are deemed hazardous.

Fifty pounds of gunpowder may kept kept on any premises; storage of larger amounts or of other explosives is limited to a specified industrial district. The manufacture, storage, sale and discharge of fireworks are prohibited; provision is made for temporary storage for re-shipment and for public fireworks displays under permit. Storage of large quantities of carbide and the manufacture of matches is restricted to the explosives district. Acetylene generators must be constructed and located in the manner directed by the Fire Marshal and not over 400 pounds of carbide may be kept for generator use outside the explosives district; requirements for shop piping and manifolding of cylinders are lacking. In building other than acid manufacturing plants, the storage of more than one carboy of nitric, hydrochloric or sulfuric acid within the building must be in a room of fire-retardant construction having sprinkler or open spray protection. Specific regulations on other hazardous chemicals are lacking. Provisions on dry cleaning plants are superseded by the detailed State law and regulations.

Regulations on motion picture film exchanges, storage vaults, and laboratories are good; buildings must be of fireproof construction, not over two stories in height, and equipped with automatic sprinklers except in non-hazardous portions. Nitrocellulose and film must be stored and used under regulations of the Fire Marshal. Good requirements on motion picture projection booths are given in the new building code.

Establishments producing or using combustible waste, shavings, straw, etc., must dispose of the material at the close of each day in such a manner as to be safe from fire. Incombustible containers must be used for ashes and for substances subject to spontaneous ignition. Open air fires are not permitted within a specified district and are permitted in the city only under permit.

Refrigerating plants are required to have machinery located in a room properly cut off from the rest of the building and to be equipped with specified safety devices.

The plumbing and heating code contains good requirements on gas connections, clearances to woodwork, vents, flues, and appliances.

A number of additional regulations are needed before reasonable control over various potential fire causes can be secured. Among the more important subjects not covered or inadequately covered at present are: Flammable liquids other than gasoline, paint and lacquer manufacture, dip tanks, enamelling ovens, tire retreading, explosive dusts, liquefied petroleum gases, flammable anaesthetic gases, storage of combustible fibers, and air conditioning.

LOCAL CONDITIONS. — Sporting goods stores commonly have ammunition in wood or paper cases. Fireworks are discharged in Chinatown during the Chinese New Year celebration. Fireworks storages occur in pier sheds and warehouses, where they are held for re-shipment. Loading or unloading of ammonium nitrate and high explosives along the waterfront are not permitted. A pure grade of ammonium nitrate is kept at one plant in 100-pound bags, 30 bags being ordered at a time. The nitrate is heated in gas-fired temperature-controlled pots to produce nitrous oxide anaesthetic in a plant which seriously exposes a 2-story school.

Bulk storage of petroleum products is confined to two industrial areas near the waterfront, a large district in the southeastern part of the city

and a smaller district in the extreme northern part. Storage tanks, including miscellaneous fuel tanks as well as those at distributing plants, are surrounded by retaining walls of sufficient capacity to hold the total tank contents. All plants, except a few of the older ones, have foam extinguishing equipment, with permanent piping to tanks. Tanks are mostly of modern, all steel construction, but in many cases they are closely spaced. Piers used by oil tankers are of wooden construction. In the vicinity of the pier at the foot of Sixteenth Street are bulk oil storage plants, storages of lumber, woodworking plant, and other nearby piers and wharves of timber construction, all forming a large concentration of combustible material. Underground pipe lines from piers to shore tanks are generally filled with water to convey the entire shipment of oil into the shore tanks. Shore filling stations for servicing small craft are supplied from tanks on land and are located almost entirely at Fisherman's Wharf, between Jones and Hyde Streets. Tank trucks carrying flammable liquids are well supervised and are well equipped.

At automobile service stations and garages, gasoline is stored in properly installed underground tanks having approved dispensing pumps. Gasoline dispensing is permitted in certain ventilated basement garages, but more commonly pumps are installed near grade-level entrances. Fifty-gallon portable tanks are in general use by industrial concerns and automobile repair shops as well as by garages.

Public and commercial garages of one and two stories generally have masonry or reinforced concrete walls and fireproof floors, with roofs of corrugated iron on light steel trusses, or of wood; those of greater height are of fireproof construction. Maintenance is ordinarily fairly good and first-aid fire protection is provided. Automobile storage space in the basements of apartment houses and hotels is cut off from other parts of the buildings by construction ranging from metal-clad wood or metal lath and plaster partitions and ceilings to those of fireproof construction, depending upon the area of the storage space. Sometimes exposed in the garage are unprotected steel columns or other members supporting 5 or 6 stories of ordinary masonry construction above. Elevator shafts and stairways terminating in garage spaces are generally protected by fire separations and fire doors. There are many districts in the city compactly built with old apartments having inferior or poorly maintained fire separation between garage and the floors above. Basement garages in office buildings are generally well cut off and mechanically ventilated, and services are usually limited to washing and lubrication. Practically no basement garages are protected by automatic sprinklers.

Spraying of lacquer and other finishes, long unregulated by ordinance, is done under unsatisfactory conditions in some older shops, but conditions in general are improved, and new installations have proper enclosures, ventilation, and electrical equipment. A temporary unenclosed spraying installation in the basement of a luxurious clothing store under construction did not have these safeguards, and smoking was not properly restricted. Flammable finishes and thinners in spray and other paint shops are kept in ordinary shipping cans or in drums on tap, sometimes over wood floors. In addition to the usual stock of paints, lacquer, and varnish in sealed containers, paint and hardware stores generally keep a certain amount of oils, solvents, thinners, and other flammable liquids in drums equipped with ordinary faucets. Glass and metal containers are filled over wood and concrete floors. Smaller paint factories are not sprinklered, and explosion-proof equipment is not always installed even though alcohol and similar flammables are handled. One large, sprinklered plant manufactures paint, varnish, and lacquer under congested conditions involving mutual exposures between the various plant operations and several flammable liquid storage tanks. The lacquer plant lacks some safety features, and inadequate yard space has resulted in storage of nitrocellulose in drums at the base of the sprinkler tank.

There are 109 licensed dry cleaning plants in the city, those using flammable solvents being located mainly in industrial and minor mercantile districts. Sixty-five employ non-flammable solvents, 20 use solvents of the 140°F. class, and 24 use solvent of the Stoddard type. Some of the latter are wholesale plants of large size. Plants comply with the good regulations of the State Fire Marshal covering construction, equipment, fire protection, and handling of solvent.

Motion picture film is stored and handled in film exchanges under good conditions. Most of the exchanges are in buildings of fireproof construction with hazardous portions protected by automatic sprinklers and fairly well cut off from the rest of the building. Vaults are mostly of standard construction and protection. Motion picture projection booths in theatres are of masonry, plaster on incombustible lath, or in some older places, metal- and asbestos-lined frame. Automatic shutters, metal film cabinets, and fire extinguishers are generally properly provided.

The prevalence of open stairways and combustible construction make the improvement of exit facilities difficult, but action of the fire and other departments has resulted in safer means of egress for public assembly buildings, night clubs, and some other occupancies. Counterbalanced stairways and ladders are being installed on some hotel, apartment, and office building fire escapes, many of which have their lowest balconies 15 to 25 feet above the ground. In some office buildings, travel distances to marked exit stairways have been made excessive on some floors by the

partitioning off of one of the building stairways within suites of offices, thereby hiding it from other occupants of the floor.

The most commonly used fuel is natural gas. Furnaces and boilers in office buildings and large plants are usually in separate fire resistive rooms, with fire doors at openings generally not of automatically-closing type. Gas appliances are connected by rigid piping except for some portable heaters and laboratory burners supplied through flexible tubing. Cement-asbestos or other Type B flue piping is commonly used except for kitchen ranges, where patent chimneys are required as a precaution in case trash-burners are installed. In most cases observed, gas flues are kept reasonably clear of combustible material. Oil burning equipments increased in number during the wartime gas shortage. They are installed in a federal housing project and are found elsewhere usually in large buildings. Installations are generally well made, with burners pump-fed from underground tanks and equipped with safety combustion controls. Flues are frequently of lined masonry up to the second floor level, with patent chimney construction above this point. Oil-burning boilers and furnaces are installed in fire-retardant rooms. Heating ducts and room dampers at an occupied wartime housing project are of plywood, but generally hot air ducts are of asbestos-covered sheet metal. One housing project uses kerosene in kitchen ranges, and a few old-type portable kerosene room heaters are used in some stores. Liquefied petroleum gas is used in plumbers' torches and in similar small-scale applications in building construction work.

Fireplaces in residential construction are usually supported on a metal plate on wood floor joists, with a course of brickwork or tile above, a type of construction that does not conform to generally accepted safe practice. Patent flues are used instead of masonry chimneys. In new construction, good clearances are observed between the fireplace and wood framing. Grease hoods and ducts, sometimes equipped with exhaust fans, are provided over restaurant ranges. Ducts are of single thickness metal and for the most part are carried up on the outside of the building wall. One duct was only about one inch from wood framing, and a few hoods were found covered by grease and lint. Walls around ranges and ovens are frequently protected by sheet metal.

Large woodworking plants are generally sprinklered and have dust-collecting and disposal systems, but some small plants have neither, and smoking was observed in a small shop in the huge wooden addition to the Ferry Building. A large sprinklered mattress plant has separate rooms for certain dusty operations, and dust hazards are minimized by exhaust systems and usually by the use of proper type electrical equipment; dust not carried away by the duct system is removed by workmen with compressed air hose. Plastic plants usually handle low- and moderate-hazard plastics, but hazards are created by storage and handling of alcohol and acetone and by pre-heating of plastic pellets before molding. In one plant inspected, surfaces of plastic articles are smoothed by applying a flame of hydrogen gas supplied from cylinders. Acetylene for welding in garages and other shops is usually supplied from cylinders. Oxygen is produced from the air at one plant which uses oil-lubricated multi-stage compressors; oxygen and hydrogen are produced electrolytically and the hydrogen stored in a gas holder inside the building and in the vicinity of ordinary electrical equipment. Tire retreading plants usually have dust-collecting systems for buffers, but gas-fired steam molds are not always sufficiently separated from where rubber cement and solvent are handled. Sulfur is stored and refined in a brick chemical plant building which is subdivided by fire walls; frequent fires reportedly occur in subliming chambers but have been extinguished by workmen familiar with the hazard.

Rubbish conditions in the mercantile district generally appear to be fairly good, although a few large accumulations of flammable waste material were noted in stores and industrial establishments. In a new garage building, paper containers are used for rubbish. Rubbish collections are made by private contractors, the frequency of such collections being optional with the building owner or occupant, an arrangement which tends to result in waste material being kept on the premises for an undue length of time.

Hand extinguishers on the whole are well distributed in occupancies where needed, and only a few were found obstructed or of unapproved type. Sand was lacking in sand buckets in a garage, and extinguishers were not provided at lumber storage, power saw, or elsewhere at a large office building under construction. Wheeled soda-acid extinguishers are provided in pier sheds and other large buildings.

CONCLUSIONS.—Practices of the Division of Fire Prevention and Investigation have changed little during the past several years. Exceptionally good attention is paid to hazards and exits in new construction and alterations through close cooperation with the Bureau of Building Inspection. Investigations and follow-up work in connection with permits and complaints occupy considerable time. However, these duties and the limited personnel available preclude block-to-block inspections on a systematic basis, which are usually considered one of the main functions of a fire prevention bureau and which are essential for the detection and correction of fire hazards in commercial and industrial buildings that would not otherwise be visited. There is at present no organized training program, and

an appreciable number of inspectors are relatively inexperienced. Very little public relations and educational work is done.

The division of authority over various classes of permits is a situation warranting improvement. The fire code, although amended to cover some additional hazards, is still inadequate to cover flammable liquids other than gasoline, dust hazards, paint and lacquer manufacturing, compressed gases, hazardous chemicals, and combustible fibers. Regulation of these hazards can be made more effective by use of specific ordinances than by the broad discretionary powers that are granted in many cases to the Chief of the Division. A general revision of the code is needed to eliminate conflicting provisions and uncertain legal status. Conditions in various occupancies as a whole are fairly good but are unsatisfactory or hazardous in some occupancies.

ELECTRICITY

ORGANIZATION AND CONTROL.—General.—The installation of electric wiring within buildings has been supervised since 1900 by the Municipal Department of Electricity. This department is placed by city charter under the general control of the Chief Administrative Officer of the city and in direct charge of a Chief of Department. Duties of the department include the enforcement of ordinances and regulations governing electric wiring and equipment in or upon buildings and streets, as well as construction and maintenance of the fire alarm telegraph, police, and traffic signaling systems.

Subsequent to the death of Ralph W. Wiley, Gordon C. Osborne, plant superintendent, was given the emergency appointment of Chief of the Department of Electricity. Appointment was on February 10, 1948, effective for a period of 90 working days or until a permanent appointment is made from the civil service eligible list. After the retirement of Chief Inspector Harold Gerber, direct charge of electrical inspection work was placed under James A. Graham, appointed Chief Inspector August, 1947, after placing first on the civil service examination. He has had experience in outside wiring for the city since 1920 and at various times has worked on interior wiring. The inspection division includes 14 field inspectors, 2 office men, one inspector for outside wiring, 2 clerks, and a cashier. Six automobiles are provided for inspectors working in other than congested districts.

Permits, Inspections and Records.—Written application on duplicate forms must be made and a permit obtained for the installation of all interior wiring, fixtures and equipment, and for signs. Application forms require complete data on the proposed work and wiring diagrams must be submitted except for small installations. Permits are posted on the job, to be signed by the inspector as work progresses and is approved. Upon approval of rough wiring a blue sticker is posted at the meter board which permits concealing of the work. After final inspection and approval a green sticker permits the power company to supply current. A formal certificate of approval is also issued to the contractor when the installation is completed.

The city is divided into districts with an inspector assigned to each district. One copy of the application form is used by the inspector for checking and for his field notes. Written notice of defects to be corrected is sent to the contractor in each case. Undue delay in the correction of such defects results in assessing the contractor additional fees, or in extreme cases, of withholding permits on succeeding applications. All wiring is inspected at least twice, before being concealed and on completion; an average of 3 inspections are made per approved installation. Special inspections and reports are made on defective wiring installations noted by the inspector in the course of his work or reported as a complaint. No regular reinspections of old wiring are made, but when changes or additions are made to an existing installation the old work must be made safe. Routine inspection work appears to be kept up to date, and requests received for inspections are generally fulfilled on the following day.

One inspector spends part of his time enforcing the ordinance restricting the sale of electrical goods to approved devices and materials; passage of a recent sales licensing ordinance is expected to enable the appointment of two additional men on this work. When unapproved goods are found, written notice to stop sale is sent to the dealer.

Complete records are kept of each wiring installation, including application forms, with inspection notes, certificates of approval, special complaint and other reports, and correction notices sent out, as well as inspectors' daily reports. A log book record of each job is also kept. Records are conveniently filed, permanent records by street and number, others by contractor, district or by reinspection date to insure attention at proper time.

LAWS AND REGULATIONS.—The Electrical Safety Orders of the State Division of Industrial Safety, effective May 1, 1934, and applicable to places of employment, include most of the provisions of the National Electrical Code and also contain additional requirements for working space and guarding around electrical equipment. All materials and devices must be of approved character. These orders are enforced by cooperation between State and city

inspectors. Outside wiring is regulated by general orders of the State Public Utilities Commission.

The electrical ordinance of 1936 requires that all wiring and fixture work must be done in accordance with the requirements of the National Electrical Code and of the State Electrical Safety Orders. Authority is given to the chief of the department to promulgate such additional rules, or modifications and interpretations of these standards as he finds necessary and no certificate of approval may be issued for an electrical installation unless it complies with all such rules. A number of supplementary regulations have been issued. The use of armored cable, nonmetallic sheathed cable, and open wiring is prohibited, and concealed knob-and-tube work is permitted only in dwellings, flats, and certain apartments. Separate ordinances cover the installation and maintenance of signs, and the wiring in buildings used for public assembly. Adequate authority is given to cause the correction of wiring defects and to cut off current supply from installations found to be in a dangerous condition.

An ordinance of 1931 governs the sale of materials, devices and appliances and requires that such products meet with the approval of the chief of the department of electricity, who is empowered to promulgate necessary rules and specifications; conformity with Underwriters' Laboratories' standards is considered evidence of conformity to requirements of the ordinance. Inspection personnel to enforce this ordinance properly is lacking.

Electricians must pass an examination and electricians and plant owners who employ electricians are required to be licensed.

Ordinances passed at various times since 1899 require that outside wiring within specified districts or along certain streets be placed underground, except for trolley wires and feeders and portions of street lighting circuits necessarily aboveground. Authority is given to require annually the elimination of overhead wires from 2½ miles of streets, contiguous to existing underground area. The present underground area includes practically all of the congested value district, with considerable adjoining territory and a number of important streets radiating therefrom.

INSIDE WORK.—During the compilation of this report, an examination of a number of representative installations was made to ascertain the quality of supervision maintained and the general condition of interior wiring. Installations inspected included old wiring, wiring completed and approved within the past few years, and installations in course of construction.

New work has been supervised in a competent manner and when finally approved complies with local and State rules. New wiring systems are generally installed with sufficient circuit capacity to care for a reasonable increase in load. Approved materials and devices are used; rigid conduit or electrical metallic tubing is generally used as required by ordinance. Wartime provisions permitting relaxation of certain requirements are being withdrawn.

The chief problem in this city is the difficulty of controlling changes in wiring made subsequent to approval of the original installation. Owing to the lack of systematic reinspections, many wiring installations gradually become defective, chiefly by misuse of flexible cord, overloading of circuits, overfusing, and addition of unauthorized extensions. While some of this work is noted and corrected by the inspectors during the course of their regular work or upon response to complaints by citizens or other city departments, some comprehensive scheme of reinspections will be necessary before the defective conditions resulting from gradual deterioration of wiring systems can be found and corrected.

OUTSIDE WORK.—The placement of distribution wiring underground was suspended during the war, but the practice has been resumed, according to ordinance. Services from the underground system enter buildings in underground conduit, a separate service being generally provided for each building. In the underground area transformers are mostly in street vaults, a few being in fireproof rooms within large buildings; elsewhere they are mounted on poles. Joint poles for overhead work and separate underground conduit systems are used by the wire-owning utilities. Overhead wiring obstructions in the congested value district and vicinity are slight; elsewhere throughout the city the amount of overhead wiring is considerable.

Electric current is generated at steam plants both within and outside the city and at distant hydro-electric plants. Emergency connections can also be made to the transmission systems of companies operating in adjoining territory so that interruptions of power supply should be of very short duration. Tie lines between substations are chiefly 11,000-volt circuits. Primary distributing circuits from substations are partly 4,000-volt and partly 11,000-volt lines, stepped down ordinarily to 120-240 volts for consumers' use, using the 3-wire grounded neutral system. Industrial plants frequently have 480-volt power installations. Part of the underground district is supplied by a secondary network, a 4-wire system operating at 120-208 volts. Some direct current is furnished for commercial power. The municipality operates the local and interurban electric street railway systems, using the overhead trolley and rail return at about 600 volts direct current. A few street car lines have been replaced by engine-driven or trolley buses.

ELECTROLYSIS.—A report on electrolysis conditions as they affect the high pressure system was completed by the municipality in April, 1938. A potential survey covering the entire system was made, supplemented by quantitative measurements of current carried by the pipe at a number of locations. Five major areas were disclosed where pipe was positive to street railway rails and where electrolytic corrosion might be expected through current leaving the pipe. At such points cable bonds are installed between the pipe and the negative returns of the rail system to drain off the current without damage. No change in protective arrangements have been made since 1938, and no electrolytic damage is reported.

The water department reports no damage to the cast-iron mains of the domestic water system; these mains have been laid with cement joints since 1917, a factor which tends to reduce their current-carrying capacity. Likewise no trouble has been experienced on the thinner-walled steel pipe. Fire alarm cables are bonded to telephone cables which in turn are bonded to negative returns of the street railway systems to drain off stray current at definite points and under known conditions. The telephone company reports an average of approximtaely 30 cases yearly of electrolytic damage to cables. Some additional drainage bonds have been installed and the telephone company assigned 8 men and 3 trucks in January, 1948, to begin a 3-year survey of electrolysis conditions.

Occasional damage to underground power cables has occurred. Steel or wrought iron gas mains have been affected to some extent, but no known damage to cast-iron mains has occurred.

CONCLUSIONS.—The electrical department is under a new chief, and inspection work is under a recently appointed chief inspector. Ordinances and regulations are such as to insure a good class of work and are apparently well enforced. The attention paid to old wiring is limited, however, and a number of wiring installations inspected indicated that some program of periodic reinspections is necessary if defective conditions resulting from the gradual deterioration of wiring systems are to be found and corrected. Outside wiring is practically all underground in an extensive district which includes the congested value district; throughout other sections of the city the amount of overhead distribution wiring is considerable. Some damage has been caused by electrolysis and indications are that underground structures in various parts of the city are carrying considerable current, but corrective measures have provided generally good control.

CONFLAGRATION HAZARD

CONGESTED VALUE DISTRICT.—Limits.—Beginning at Mission Street and the Embarcadero: Mission, Beale, Howard, First, Tehama, Second, Folsom, Hawthorne, Howard, Third, Minna, Sixth, Stevenson, Seventh, Market, Jones, Eddy, Leavenworth, Ellis, Hyde, Post, Larkin, Bush, Mason, Pine, Stockton, Jackson, Montgomery, Pacific, Sansome, Broadway, Front, Clay and the Embarcadero to place of beginning.

General.—The district is in the extreme northeastern portion of the city, bordering on the Embarcadero along the waterfront for a distance of 800 feet. It has an extreme length of 7,200 feet, a maximum width of 4,500 feet, and is of irregular shape. The bounding streets include an area of 526 acres containing 185 blocks; 35 per cent of the area of the district is in streets and 84 per cent of the block area is built upon. About one-fourth of the district is on filled ground; this portion and the area south of Market are level; elsewhere the ground rises to the north and west, in generally moderate grades except on the slopes of Nob Hill where the grades reach a maximum of 25 per cent. Elevations range from 0 to 214. Streets are all paved and in good condition. Except for trolley wires, there are practically no overhead wire obstructions to hamper fire department operations.

Market Street is 120 feet wide. The principal streets south of it are 82 feet and those to the north are chiefly 69 feet in width, except California Street which is 82 feet wide and those north of and parallel to it, which are 49 feet; 29 and 77 per cent of the total length of streets are respectively under 50 and under 80 feet in width.

The main retail mercantile, office and financial area extends through the center of the district, from one to four blocks north of Market Street and generally one block south of Market. The more southerly portion of the district contains wholesale mercantiles, loft buildings and warehouses, with some manufacturing. The western part consists mainly of hotels and apartment houses. In the northeastern quarter are miscellaneous occupancies including warehouses, some manufacturing, produce dealers, loft buildings and smaller mercantiles. A group of about 12 blocks in the north central part of the district is of Oriental occupancy.

The only natural fire breaks within the district are three small parks. The width of the Embarcadero reduces considerably the exposure along a part of the eastern boundary from waterfront construction, and the general exposure on the east and northeast is moderate from mercantile and industrial buildings. On the north and west, the district is exposed by closely-built, excessive-height apartment house districts. Blocks on the north, except those on the crest of Nob Hill and

except for the fringe of blocks included within the fire limits, are built almost entirely of wood frame construction. The fireproof construction and open spaces on Nob Hill, together with the slope downward to the congested value district, are valuable features in one section but are not of sufficient extent to avoid a very severe over-all exposure. On the west extending to Van Ness Avenue, blocks are built with ordinary masonry construction having few features to resist spread of fire, and except for the relief offered in the southwest by the fireproof construction and open spaces of the Civic Center, the exposure is very severe. South of the district the congestion is not as marked and heights of buildings, which are of varied occupancy, are lower except along some of the boundary blocks; intermingled frame and ordinary construction form an exposure classed as severe.

Potential Hazard.—The majority of blocks are of small or moderate area, chiefly 270 by 410 feet; most of those south of Market Street are 810 feet long and vary in width from 145 to 340 feet; 23 are of large or excessive size, the largest covering 6.4 acres. Few blocks have alleys or driveways extending through the block; 84 blocks are solidly built, with very little or no interior vacant space, but about half of these are small or narrow blocks with buildings extending from street to street. Thirty-nine blocks have more than 50 per cent of their buildings accessible from only one side and are classed as inaccessible to the fire department.

Buildings of fireproof construction cover 34 per cent of the built-on area. In the central portion of the congested value district, from Fremont to Sixth Street between Mission Street and a line parallel to and approximately 1,400 feet north of Market Street, fireproof construction occupies 49 per cent of the area built upon. Under ordinary conditions this percentage of fireproof construction should prevent a fire, originating within the area, from assuming disastrous proportions or a fire, originating without, from penetrating any great distance into the district. Slightly more than one-third of these buildings have protected windows; blank exterior walls are fairly frequent.

Sixty-five per cent of the total construction in the district is composed of ordinary buildings with masonry walls and wooden interiors, often with reinforced concrete or unprotected structural steel framing in the higher buildings. Heights are frequently excessive, 77 buildings being 7 or 8 stories; 23 per cent are 5 stories or over in height. The percentage of this class of construction which is of excessive area is moderate, although 55 per cent is in areas classed as large or excessive. Floor openings are properly protected in very few buildings. Walls of buildings are generally in good condition, and parapets are provided; the number of communicating openings between buildings represents 10 per cent of the total number of buildings; about three-fourths have some measure of fire door protection. Window protection is small in amount and this general lack of protection to exposures is a serious factor in increasing the number of buildings which are potentially subject to one fire.

The amount of frame construction, which includes all-metal buildings, is very small, well distributed, and does not appreciably increase the conflagration hazard in the district.

The potential hazard is greatest in the western and northern parts of the district where many blocks are closely built with readily combustible buildings of excessive height, mutually exposing through unprotected windows and light courts. In the contral portion of the district, where the percentage of fireproof construction is greater, and south of Market Street, where heights of buildings are generally lower and blank division walls more frequent, the potential hazard is moderate.

Probability Hazard.—The municipal fire protection in the congested value district is exceptionally strong. Ample quantities of water are available from the high pressure system, which was designed and constructed with unusual precautions against damage by earthquakes, and considerable water is also available for supply to pumpers from the domestic system. The fire department, although handicapped by considerable old and some obsolete equipment, is a well-manned and fairly well-trained force. Private fire protection is small in amount, only 10 per cent of the built-on area being protected by automatic sprinklers. On the taller buildings, outside standpipes are of assistance to the fire department in combatting serious fires. High winds are very frequent and earthquakes of sufficient intensity to crack masonry walls have occurred 9 times in the past 140 years.

Under ordinary conditions the fire department should be able to confine a fire well under way to one block, or possibly two blocks if the blocks are separated only by a narrow street. Perhaps the worst factor entering into the conflagration hazard is the presence on the north and west of the congested value district of the large closely-built apartment house areas. Portions of these areas are 1 to 3 blocks from high pressure system protection. This exposure particularly affects the western third of the district, the slope of the ground in some sections being favorable toward preventing a conflagration from reaching the central part of the district.

The Chinatown section, consisting of the blocks on either side of Grant Avenue from Bush to Jackson Streets, offers conflagration possibilities. Although areas are mostly small and unpierced masonry walls on lot lines are frequent, compact blocks of ordinary masonry buildings form severe mutual exposures across narrow streets.

In the central part of the congested value district, owing to the greater percentage of fireproof construction, and in the southern part, because of lower buildings and more division walls, the probability of fires beyond control of the fire department is low.

In the event of a severe earthquake, both water systems will undoubtedly suffer serious damage. Good valve spacing should permit isolation of damaged sections of the high pressure system, and it seems reasonable to assume that portions of the system on firm ground will remain intact and that some of its several sources of supply will be undamaged, enabling the fire department to make a stand against a sweeping fire. In addition, the fire department pumping equipment can operate effectively at draft from the Bay, and a good supply of hose is provided, including considerable 3½-inch hose, so that a considerable portion of the business district near the waterfront could be afforded some protection without recourse to the high pressure or domestic water systems. The cisterns located in the more closely built parts of the city may also be of considerable value. Successful handling of the multiplicity of fires which may be expected in a disaster of this kind depends to a large extent upon the maintenance of communication facilities for receipt of alarms and dispatching of fire companies. An uncontrollable peak load may make the telephone system useless for this purpose; the fire alarm system has been designed with a view toward minimizing earthquake damage, but its value will depend largely upon the extent to which underground cables remain intact.

Under conditions of maximum damage to the fire protection facilities, it seems fair to predict that the fire department would still be able to confine a conflagration within reasonable limits and that the entire congested value district should not become involved; the destruction of groups of several blocks is to be expected, particularly outside of the central section of the district.

OTHER DISTRICTS.—Main Wholesale and Industrial District.—South of and adjoining the congested value district is the main wholesale and industrial district, bounded roughly by Mission, Fourteenth, Folsom, Twentieth, Iowa, and Twenty-fifth Streets, and the waterfront. Bordering the congested value district are many wholesale, some retail, and light industrial occupancies rather closely built. Congestion and building heights decrease toward the south and east, as the character of occupancy becomes predominantly industrial, and included are various manufacturing plants, warehouses, freight terminals, lumber yards, wood and metal working plants, oil storages, and a shipyard. Construction is fairly evenly divided between ordinary masonry and frame, and there are groups of wood frame dwellings, flat buildings, and apartment houses. A few plants are of superior construction and a moderate number are equipped with automatic sprinklers.

The northern half of the industrial district is well protected by the high pressure system which also extends through the remainder but covers it less completely. The domestic water system in this latter section is reasonably adequate. A fairly large proportion of the district is on filled or unstable ground, making it especially susceptible to damage from earthquake shocks which would be likely to put the water supply system out of service. On this unstable ground are many of the more hazardous groups of buildings. Serious group fires covering considerable areas may be expected at a number of points where a congestion of frame and non-fireproof construction exists, but on account of the proportion of open space no general conflagration should occur. Because of greater congestion in the north, mutual exposure between this district and the congested value district is severe. The prevailing direction of winds is such as to drive a fire in the industrial district toward the bay and away from the congested value and residence districts.

Other Industrial Districts.—Extending from Bay Shore Boulevard east to the waterfront are two industrial sections, one covering about one square mile in area south of Army Street and the other, about one-fourth of a square mile in area, located mainly between Williams and Paul Avenues. A part of the former has high pressure system protection. There is considerable open space, but groups of non-fireproof buildings in some blocks and the extensive areas covered by some frame warehouses and plants create the probability of severe individual to block fires. Immediately south of Islais Creek is a group of packing houses, slaughter houses, grain terminal, and several oil storages, nearly all of which are of frame construction. An extension of the high pressure system, supplied through a single main, protects the area, and adequate supply is also available from the domestic water system. Unless both systems fail, the fire department has a reasonable chance of controlling a conflagration in this area.

Bounded by the northeast line of the congested value district, Sansome Street, the base of Telegraph Hill, Francisco, Hyde and the Embarcadero is the northeast industrial district. In the southern end of this section, adjoining the congested value district, the blocks are compactly built with ordinary and frame buildings, mainly one and two stories in height, occupied by produce dealers; the central portion contains warehouses, cold storage plants and manufacturing establishments, chiefly of ordinary masonry construction; further north are miscellaneous industrial plants, including several oil storages. The district is narrow in large part, and the general conflagration hazard is low.

Waterfront. — The main waterfront development extends from the foot of Hyde Street to Sixteenth Street. Piers are of pile and deck type built over water except one, about half of which is on solid fill. Dimensions generally are from 100 to 200 feet in width and 600 to 1,000 feet in length. Of 39 piers, 20 have reinforced concrete decks supported on reinforced concrete or concrete-jacketed wood piling, 13 have wood decks on creosoted wood piling, and 5 others are mostly of this type of construction, and one is partly on solid fill. Fourteen pier sheds have frames of unprotected steel or heavy timber with reinforced concrete curtain walls, one having a reinforced concrete slab roof and the others composition-covered wooden roofs; 24 are mostly or entirely of wood construction, a few having some unprotected steel framing. Some of the buildings have frame or corrugated iron draft curtains in the roof. A number of the pier sheds combine into groups of two or more through frame structures along the bulkhead.

Two pier sheds and the bulkhead warehouse between them, which expose the San Francisco-Oakland bridge, are completely sprinklered; sprinklers are provided under one which has a wooden deck, and open heads are installed at the top of exterior walls. For the other piers, private protection consists only of wheeled and a few hand chemical extinguishers, standpipes and hose having been mostly removed. High pressure and domestic water supply protection is deficient along some sections of the waterfront, and dependence is placed on fire boats and on pumpers drafting from the bay. Clear wharf space for use of fire department pumpers is marked off at bulkheads between piers, and floors within pier sheds are equipped with manholes for pumper suction hose. Monitor nozzles are installed on roofs of the Ferry building group. Pier sheds have from 2 to 9 auxiliary fire alarm boxes in each, and a few have automatic alarm systems. Although the piers are not considered subject to a general conflagration, severe fires involving several piers can readily occur, on account of the combustible construction employed, connecting sheds and bulkhead construction between piers, possible highly flammable contents, poor accessibility to underdeck space, and the general difficulty of fighting pier fires. The largest group consists of the Ferry building which with the construction between the ferry slips and the sheds and shops, some with hazardous contents, adjoining to the north and south, covers a total area of approximately 15 acres; there is a small amount of fireproof construction and some brick or concrete, but by far the greater proportion of construction is frame.

Apartment House Districts.—In the northern and central parts of the city, extending north and west from the congested value district and from the industrial districts mentioned above to the Presidio and Golden Gate park, and south to approximately Thirtieth Street, which includes the Western Addition and Mission districts, is the highly congested residential area of apartment houses and flat buildings. A small portion of the area which lies within the fire limits, as shown on the accompanying map, is built up with ordinary masonry buildings. Minor mercantile sections are found along some of the principal streets such as Columbus Avenue, Van Ness Avenue, Fillmore Street, upper Market Street, Mission Street and a few others, and in some of these sections a fair proportion of the buildings are of masonry. Otherwise construction throughout the area is all frame, mostly three stories plus grade-level basement in height, and closely built, with only an occasional structure of better type. Almost any block in the district could form the starting point for a conflagration of disastrous proportions. Much of this area is very hilly; the steep slopes of Telegraph Hill and Nob Hill, for example, not only increase greatly the difficulties of fire fighting but also increase the probability of exposure fires.

The high pressure system covers most of these apartment house districts, including the Marina on the extreme north; mains are usually spaced at intervals of three or four blocks. The domestic water system is as a general rule not capable of furnishing sufficient water to handle a block fire. Small parks within the area would be of little assistance in checking a conflagration; Van Ness Avenue forms a partial firebreak as it is 125 feet wide and is built up largely with fireproof or masonry construction with some protected windows, and upper Market Street, of fair width, constitutes a partial separation. Structurally there is no defense against a sweeping fire and the safety of these districts depends entirely on the public fire-fighting facilities. As previously noted, a part of the frame apartment house area abuts directly on the western and northern boundaries of the congested value district and forms a very severe exposure to it. The prevailing direction of winds is such as to drive a conflagration into the high value commercial and industrial districts.

Other Residential Districts.—The Richmond district north of Golden Gate Park is closely built with frame buildings. Minor mercantiles of frame construction are found along Geary and Clement Streets, but most of the buildings are apartment houses or flats, with a fair proportion of dwellings. Typical block construction consists of a solid ring of frame structures along all four sides of the block, with an inaccessible open area in the block interior. Parts of the district, particularly the eastern portion, contain numerous blocks closely built with three-story and grade-level basement frame buildings and are subject to conflagrations. The water supply under normal conditions is fairly adequate.

Similar conclusions may be drawn for other districts in the city, such as the Sunset district south of Golden Gate Park, and areas in the southern part of the city, although here the buildings are generally of lesser height and congestion is less. Dwellings have fire retardant roof coverings. In the smaller apartment house districts the water supply in most cases is reasonably adequate, but in some of the dwelling districts it is insufficient. Part of the Sunset district is distant from fire department protection.

GENERAL FEATURES.—There are several distinct fire breaks or barriers in the city. Golden Gate Park, over ½-mile wide, separates the Richmond residential district from the Sunset district. Traversing these districts themselves are Park-Presidio Boulevard and Sunset Boulevard, each about 400 feet in width. Extending in a southeasterly direction from the southeastern corner of Golden Gate Park are the open areas of Sutro Forest, Twin Peaks, Mount Davidson, McLaren Park, and other hills and parks. The fire break formed is not continuous, being broken by a 2-block wide residential strip connecting the Sunset district with the Western Addition at Golden Gate Park and a wider strip along Mission Street connecting the southern residential area with the Mission district. The Embarcadero, 200 feet wide in large part, separates the entire northeast portion of the waterfront from the rest of the city. Bordering the northeastern industrial district in part are the precipitous slopes of Telegraph Hill which form a partial barrier against the apartment districts to the west. Other barriers and parks in the city are of only local value as fire breaks. Several streets are of fairly good width, such as Market Street, 120 feet wide, extending southwesterly from the waterfront to Noe Street and dividing high value districts on either side. Van Ness Avenue, 125 feet wide, extends from the northern waterfront to Howard Street and divides congested apartment and mercantile districts. Dolores Street, which traverses the Mission district, is 120 feet in width.

CONCLUSIONS.—In the congested value district, the potential conflagration hazard is high for the western and northern portions and somewhat lower for the central and southern portions. Fire-fighting facilities are excellent and under normal conditions a fire should be confined to a single block or possibly two if the separating street is narrow. The worst feature is the very severe exposure to the district by highly congested apartment house areas to the north and west, which are easily capable of developing conflagration against which the western part of the high value district offers little structural defense. In the event of a severe earthquake, both the domestic water system and the high pressure system will undoubtedly be badly damaged, but it seems reasonable to assume that portions of the high pressure system will remain intact and that this and other emergency water supplies will enable the fire department to make a stand against a conflagration and confine it within reasonable limits.

In the industrial district south of Market Street serious group and block fires may be expected at a number of points where a congestion of nonfireproof construction is found, but on account of the amount of open space no general conflagration should occur. Many piers and pier structures along the waterfront, on account of their construction and lack of automatic sprinkler protection, are subject to severe individual to group fires.

The apartment house areas in the northern and central portions of the city, several square miles in extent and solidly built with frame construction, have an extremely high potential hazard, and the probability of serious fires is materially increased by the frequency of high winds. Almost any block within the area could form the starting point for a conflagration and the future existence of these districts depends upon the ability of the fire department to suppress fires in their incipiency. More outlying residential districts are subject to conflagrations where thickly built groups of frame construction occur, but the area likely to become involved in one fire is much smaller.

RECOMMENDATIONS

Recommendations marked with a star (★) are deemed of most importance and their early adoption is urged.

WATER SUPPLY

1. That the gridiron system be strengthened by the laying of 6-inch or larger mains in areas now supplied by 2-inch pipes, by replacing with larger sizes 4-inch mains used for hydrant supply, by eliminating dead ends wherever possible, by connecting large mains to minor distributors at more frequent intervals, and by the early installation of the mains listed in the table below. The following to be adopted as the standard minimum sizes of mains used for hydrant supply for all future installations:

   a. In residential districts, 8-inch; 6-inch to be used only where they complete a good gridiron and in no case in blocks 600 feet or more in length.

   b. In mercantile, industrial and apartment districts, 8- and 12-inch; the former to be used

RECOMMENDED MAINS

Domestic System

Size, Inches	Along	From	To
	University Mound Service		
30	Broadway and Columbus Ave.	Montgomery St	Bay St.
20	Third St.	Thornton Ave.	Key Ave.
16	Bay, Polk, Francisco, Laguna, Chestnut Sts.	Hyde St.	Broderick St.
16	Oakdale Ave.	Industrial St.	Third St.
12	Bush St.	Kearny St.	Montgomery St.
12	Golden Gate Ave.	Larkin St.	Taylor St.
12	Beale and Brannan Sts.	Bryant St.	Third St.
12	Mission St.	Seventeenth St.	Twenty-first St.
	College Hill Service		
20	Duboce Ave. and Buchanan St.	Guerrero St.	Hermann St.
12	Hampshire and Seventeenth Sts.	Mariposa St.	Rhode Island St.
	Sunset Service		
16	Post St.	Franklin St.	Leavenworth St.
16	Steiner and Green Sts.	Pacific Ave.	Larkin St.
12	Laguna St.	Pacific Ave.	Green St.
12	Franklin St.	Pacific Ave.	Green St.
	Presidio Heights Service		
16	Webster, Sacramento, Gough & Clay Sts.	Clay St.	Franklin St.
12	Larkin, Clay, Hyde & California Sts.	Washington St.	Jones St.
12	Leavenworth St.	Pacific Ave.	Union St.
	Lombard Street Service		
12	Union St. and Grant Ave.	Stockton St.	Chestnut St.
	Stanford Heights Service		
20	Marietta Dr., Encline Ct., DelVale Ave., O'Shaughnessy Blvd., and Congo St.	23½-inch main in Terasita Blvd.	Joost Ave.
	Merced Manor Service		
16	Forty-fourth Ave., Rivera St. and Forty-seventh Ave.	Santiago St.	Irving St.

only in sections where they complete a good gridiron and the latter for long lines not cross-connected.

★2. That the distribution system be equipped with a sufficient number of gate valves so located that no case of accident, breakage or repair to the pipe system in high value districts will necessitate shutting from service a length of main greater than the side of a single block, or a maximum of 500 feet, or in other districts lengths greater than two sides of a single block, with a maximum of about 800 feet.

3. That all valves be inspected yearly and large valves more frequently.

4. That the number of hydrants maintained on the domestic distribution system be sufficient to provide:

a. In the congested value district, at least two hydrants at each street intersection, and sufficient intermediate hydrants in long blocks so that the average area served will not exceed 40,000 square feet.

b. In minor mercantile, industrial and apartment districts one or two hydrants at each street intersection and sufficient other hydrants to provide an average area served of 60,000 to 80,000 square feet.

c. In residential districts, one hydrant at each street intersection, and sufficient other hydrants to produce an average area served of 100,000 square feet.

5. That hydrants with 4-inch connections to mains, small barrels or valves, or single 2½-inch outlets, be replaced with hydrants able to deliver 600 gallons a minute with a friction loss of not more than 2½ pounds.

FIRE DEPARTMENT

6. That the fire commission delegate more authority to the chief in the administration of the department, particularly with regard to discipline.

7. That the chief be appointed for an indefinite term with removal only for suitable cause after public trial.

8. That retirement from active duty be made compulsory for all company members upon reaching the age of 62 years.

9. That sufficient additional battalion chiefs be appointed to provide one on duty at all times in each battalion district.

10. That the service be improved as follows:

a. Provide hose wagons equipped with turret pipes for Pumper Companies 16, 35 and 46.

b. Establish a pumper company equipped with 750-gallon pumper and 100-gallon water

tank in the proposed new station near 32nd Avenue and Ortega Street.

c. Equip Ladder Companies 1, 2 and 13 with 100-foot aerial ladder trucks, Ladder Companies 3, 4, 5 and 8 with 85-foot and, eventually, all other ladder companies with modern aerial ladder trucks, all carrying ladder pipes.

d. Establish ladder companies equipped with modern aerial ladder trucks at Station 16 and the proposed station at 32nd Avenue and Ortega Street.

e. Relocate Pumper Company 27, Ladder Company 6, Booster Tank Company 9 and Salvage Companies 2 and 2a in a new station to be built as contemplated in the vicinity of Market and Sanchez Streets.

11. That the following equipment be furnished where not already provided:

a. To each pumper: Two portable extinguishers of approved type, portable electric lights, a hose clamp, 1⅛-inch nozzle tip and, in districts not covered by salvage companies on first alarm, 2 salvage covers.

b. To each ladder truck: Two portable extinguishers of approved type, portable electric lights, a hose roller, cellar pipe, portable monitor, self contained breathing equipment, a spray applicator and, in districts not covered by salvage companies on first alarm, 4 salvage covers.

c. To each salvage wagon: An auger and 5 hooks.

d. In each fire station: A rectifier for charging vehicle batteries.

12. That a survey of the structural conditions of fire stations be made and those in hazardous condition be rebuilt, also that future stations be designed and constructed with adequate resistance to lateral forces using a seismic factor of at least ten per cent.

13. That the rules and regulations be revised and issued to all members and their provisions be rigidly enforced.

14. That training facilities include a drill building with ample room for the operation of apparatus working with streams under simulated fire ground conditions, and a pump school where all operators can be thoroughly instructed in proper pump operation both at draft and at hydrants.

15. That periodical inspections of buildings supplemented by sketches be made by company members and that conditions found be used as material for discussion at officers' and company schools.

FIRE ALARM SYSTEM

16. That apparatus and instruments be installed as follows:

★a. At Headquarters: Mechanical transmitters with facilities to operate interchangeably over primary and secondary alarm circuits; a time stamp for incoming alarms; direct acting tapper in each box circuit; devices to give visual and audible indications of circuit opening and dangerous diminution of line current; heavy current fuses and approved arresters for all entering conductors; and provisions for telephonic communication over box and alarm circuits.

b. At Each Fire Station: Arresters on circuits entering from aerial construction, a gong in the primary alarm circuit and either a direct acting tapper or amplified voice or graphic recording equipment in the secondary alarm circuit.

17. That the reliability of the system be increased by:

★a. Rearranging and adding box circuits so that the area served by each will not exceed that covered by 20 boxes, properly placed, if the circuit is wholly or partly aerial wire, or by 30 boxes, properly placed, when the circuit is wholly in underground cable.

b. Adding sufficient alarm circuits so that not more than 5 fire stations will be connected to any one circuit.

c. Extending underground construction in approved cable and removing circuits from poles carrying other than signaling wires.

★18. That the practice of replacing boxes of plain interfering and other obsolete types with boxes of modern succession type be adopted.

19. That box locations be indicated by designating lights in high value and congested districts.

20. That sufficient members be added to the maintenance force to permit resumption of monthly box tests.

BUILDING DEPARTMENT

21. That the few features of the building code that are liberal in regards to safety from fire be revised to conform with the standards contained in the National Board of Fire Underwriters' Building Code, especially as to building heights and areas.

★22. That the fire limits be extended to include additional area as follows:

On the north from the existing limits between Van Ness Avenue and Stockton Street to Washington Street.

On the south from the existing limits to Townsend, Division, Eleventh, Harrison, Fourteenth, Guerrero and Market Streets.

One-half block in width on either side of principal streets which tend to develop as minor mercantile districts, such as Columbus Avenue, Van-Ness Avenue, Geary Street, upper Market Street, Mission Street, Valencia Street, and others, with the object of establishing fire breaks through the areas of highly congested frame construction.

FIRE PREVENTION

★23. That the personnel of the division of fire prevention and investigation be increased in number and that the division be so organized, trained, and equipped that greater attention can be paid to regular and systematic inspections of all commercial and industrial buildings at suitable intervals.

24. That ordinances governing hazardous occupancies and the use, handling and storage of explosive or highly flammable substances be revised and brought up to date where necessary, and additional regulations adopted to form a complete modern fire prevention code. It is recommended that the Suggested Fire Prevention Ordinance of the National Board of Fire Underwriters be used as a guide in framing the new code.

ELECTRICITY

25. That additional men be appointed to the inspection force to permit the reinspection of old wiring on a systematic and thorough basis, and to provide closer supervision over the sale of electrical materials and devices.

CONFLAGRATION HAZARD

★26. That owners of existing defectively-constructed buildings which involve serious life hazards or are so located as to form conflagration breeders be required to protect floor, party wall and exposed window openings.

★27. That approved automatic sprinkler equipments be required in all basements used for storage or for mercantile purposes and in all buildings which by reason of their size, construction, or occupancy, involve serious life hazard or might act as conflagration breeders.

GENERAL SUMMARY

City in General.—Population about 800,000. Important industrial, commercial and shipping center. Surface hilly. Grades mainly moderate in congested value district; many are steep elsewhere. High winds frequent. Temperatures mild. Severe earthquakes relatively frequent.

Water Supply.—Municipal works. Officials competent and experienced; employees under civil service. Records generally good. Emergency operations fairly good. Ample supply from three gravity sources including Hetch Hetchy; emergency supply from Lake Merced, within city. Storage in city adequate. Distribution in 17 services. Most important services supplied by gravity; others by pumping at non-fireproof stations with small equalizing storage. Consumption moderately low. Pressures fair and fairly well sustained under heavy draft. Main arteries to closely built areas in duplicate; few secondary feeders. Minor distributors mainly small; gridironing good; dead ends rather numerous. Gate valves widely spaced; in good condition; not regularly inspected. Hydrants in excellent condition; many small; spacing good in most high value districts but wide elsewhere. Large storage in cisterns.

High Pressure Fire System.—Municipal system supplying hydrants only. Covers most high value districts. Organization good. Supply ample from reservoir and inexhaustible from San Francisco Bay. Two fireproof pumping stations very substantially constructed; equipment of satisfactory type, sufficient capacity and well maintained. Distribution system strong, of ample capacity and designed to maintain service under earthquake conditions. High pressures. Gate valve spacing excellent. Hydrants of suitable type and size; condition excellent.

Fire Department.—Full paid; on 60-hour a week basis. Fire commissioners and chief recently appointed. Members below grade of deputy chief appointed and promoted under civil service. Many members old. Companies mainly adequate; generally well manned. Only 4 ladder companies equipped with aerial ladders. Salvage service limited to the northeastern part of the city. Small stream service good except in Sunset district. Condition of apparatus, fair. Several important appliances for heavy and small streams, minor equipment and self contained breathing equipment lacking or inadequately supplied. Hose well supplied and regularly tested but large amount over 7 years old. Several fire stations in poor condition and nearly half subject to severe damage in case of earthquake. Administration of discipline by previous board members has been unduly lenient. Fire college recently inaugurated for company officers and firemen. Drill tower practice, good. Special training needed for pumper operators and drivers. Response to alarms well arranged and mainly adequate. Company members lack sufficient knowledge of structural conditions and hazards in buildings in their districts. Records good.

Fire Alarm System.—Operated and maintained by the department of electricity. Manual system of local design, installed in 1915. Headquarters building suitably constructed and well located. Central office apparatus deficient in transmitting, receiving and supervising devices. Circuit protection only fair. Current from rectifiers and dynamotors with 3 outside power sources and storage battery. Boxes predominately plain interfering type of municipal manufacture, well distributed in congested districts but too widely separated in outlying residential areas. Large proportion of alarm circuits and considerable part of box circuits underground in substandard cable. Circuits unnecessarily long due to interlacing. Cables well installed and maintained. Much aerial construction on combination poles. Majority of circuits serve excessive areas. Telephone facilities at fire stations good; private exchange lacks means to call and talk to stations in groups. No facilities for telephoning over box and alarm circuits. Operating force skilled; maintenance of apparatus and circuits good. Telephone alarms properly confirmed over alarm circuits. Box tests infrequent, office tests incomplete, records fair.

Fire Department Auxiliaries.—Fire marshal duties well performed. Police cooperation good. Public service corporations assist at fires. Telephone service widely distributed. Central station watch service extensive. Auxiliary and automatic fire alarm services aid prompt alarm transmission. Private fire apparatus mainly of value in the harbor.

Summary of Fire Fighting Facilities.—High Pressure system can furnish adequate quantities for fire protection in most high value districts; designed to maintain service under earthquake conditions. Domestic system from ample sources; a few localities, mainly in outlying areas, lack sufficient water for fire protection.

Fire department well manned and fairly well trained but handicapped by considerable old and some obsolete equipment.

Fire alarm system has unreliable features; much dependence upon skilled operation; majority of box circuits serve excessive areas; boxes mainly well distributed.

Building Department.—Old, inadequate building code replaced by modern code, a decided improvement deficient in only certain respects such as liberal height and area restrictions. Fire limits somewhat inadequate to protect the congested value district and very deficient for protection of minor mercantile and congested apartment districts. Hazard to life in the solidly-built, multistory frame apartment districts and in the western part of the congested value district is severe. In the congested value district fireproof construction and sprinklered ordinary masonry construction cover 38 per cent of the built-on area; remaining construction is almost entirely ordinary masonry, much of it of excessive height, with very few structural features tending to restrict the spread of fire.

Fire Prevention.—Work of the fire prevention bureau is mainly concentrated on inspection of fire safety features in new construction and in buildings being remodeled for change of occupancy, and of occupancies which require permits or licenses. Systematic inspections of commercial and industrial buildings are not being made except to a limited extent. State and municipal regulations on some hazardous occupancies are good; others are incomplete or out of date and a few important hazards are not covered except in a general way. Conditions as a whole are fairly good but are unsatisfactory or hazardous in some occupancies.

Electricity.—Installation of new interior wiring is under a recently appointed Chief Inspector. Regulations are such as to insure a good class of work, and are apparently well enforced. Attention paid to old wiring is limited and condition of some wiring installations inspected indicated the need for a systematic program of reinspections to control overloading and unauthorized additions. Outside distribution wiring is practically all underground in the congested value district and some adjoining territory; elsewhere the amount of overhead wiring is considerable. Occasional damage has been caused by electrolysis but in general this is well controlled by the corrective measures taken.

Conflagration Hazard.—In the congested value district the potential conflagration hazard is moderate to high, but fire-fighting facilities are excellent and under normal conditions the probability of an extended conflagration is relatively low. In the event of a severe earthquake, however, the conflagration possibilities hinge largely upon the extent to which the two water supply systems are damaged. It seems probable that portions of the high pressure system at least will remain in service, enabling the fire department to confine a conflagration within reasonable limits.

Industrial districts offer possibilities for severe group fires at a number of points, but no general conflagration should occur. The waterfront piers, because of construction features, general absence of private fire protection and inadequacy of public water supply, are subject to severe individual to group fires.

The worst conflagration conditions in the city occur in the frame apartment house districts, which are highly congested and partly outside the area covered by the high pressure system. Fires well under way during times of high winds would be almost certain to involve considerable area. A part of this frame apartment house area forms a severe exposure to the congested value district.

October, 1948.

National Board of Fire Underwriters

COMMITTEE ON FIRE PREVENTION AND ENGINEERING STANDARDS.

SAN FRANCISCO, CALIF.

OCTOBER, 1948

SAN FRANCISCO BAY

PACIFIC OCEAN

SAN FRANCISCO BAY

GOLDEN GATE

FORT WINFIELD SCOTT

FORT MASON

FRANCISCO ST RES.

LOMBARD ST RES.

FIRE BOAT CONNECTIONS

PRESIDIO

LINCOLN PARK

FORT MILEY

GOLDEN GATE PARK

PARK

LAKE HONDA (ON RESERVE)

SUNSET RESERVOIR

TWIN PEAKS RESERVOIR

STANFORD HEIGHTS RESERVOIR

COLLEGE HILL RESERVOIR

POTRERO HGTS RESERVOIR

CENTRAL PUMP. STA.

MERCED MANOR RESERVOIR

LAKE MERCED

UNIVERSITY MOUND RESERVOIR

WILDE AVE RESERVOIR

FROM SAN ANDREAS RESERVOIR

FROM CRYSTAL SPRINGS RESERVOIR

KEY

Congested Value District

Fire limits

WATER SUPPLY

Mains 8 inches in diameter and larger

Mains 6 inches in diameter

Mains 4 inches in diameter

Recommended mains

Mains of the high pressure system

Fire flow tests designated by numbers

Service limits

FIRE DEPARTMENT

Engine companies shown in black

Recommended companies shown in red

Companies designated by symbols

Ⓨ Pumper Ⓦ Pumper and hose Ⓣ Hose tender Ⓛ Ladder Ⓛ Service ladder

Ⓕ Fire boat Ⓗ Hose Ⓑ Blgpatrol Ⓛ Floodlight Ⓢ Salvage corps Ⓜ Mobile

Scale of Feet